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BULLETIN OF MARINE SCIENCE
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VOLUME 2 1952 NUMBER 2

THE DISTRIBUTION OF GLYCOGEN IN THE SHIPWORM, *TEREDO (LYRODUS) PEDICELLATA* QUATREFAGES.[1]

CHARLES E. LANE, GERALD S. POSNER[2] AND LEONARD J. GREENFIELD

The Marine Laboratory, University of Miami

ABSTRACT

Adult *Teredo pedicellata* has been shown to contain approximately 30% glycogen on the basis of its dry weight. This figure is achieved within six weeks after the borer first invades wood. Most of the glycogen is concentrated in the mantle, the muscles and the gills.

Teredids maintained in substantially plankton-free sea water for seven days showed no significant change in glycogen content. When denied access to wood for seven days there was a decrease of 72% in glycogen content.

The large prenatal reserves of glycogen are largely consumed during the free-living period of seventy-two hours that precedes invasion of wood by larval teredids.

Several investigators, among whom may be mentioned Collip (1921), Moore (1931), and Dotterweich and Elssner (1935), have recorded the ability of lamellibranch mollusks to survive partial or complete anaerobiosis for varying periods of time. Roch (1931) has reported that *Teredo navalis,* under certain conditions, may withdraw into the burrow with the siphons retracted and the pallets extended for as long as six weeks with no overt signs of injury. When the animal is subsequently returned to conditions more favorable, it retracts the pallets, extrudes the siphons and returns to normal activity. It is to be assumed that the oxygen tension of the water thus trapped in the burrow would be reduced to very low figures during this period of enforced aestivation.

Von Brand in his extensive review (1946) of survival of invertebrates under partially anaerobic conditions, has called attention to the utility of glycogen as a substrate for such a pattern of metabolic

1. Contribution No. 77 from the Marine Laboratory, University of Miami. These studies were aided by a contract between the Office of Naval Research and the University of Miami in cooperation with the U. S. Navy Bureau of Yards and Docks.
2. Present address: the Bingham Oceanographic Laboratory, Yale University.

activity. As is well known (cf. Soskin and Levine, 1946), the initial stages in the phosphorylative breakdown of glycogen proceed normally in the absence of oxygen. One of the objectives of this study was to determine whether the Teredinidae contain sufficient glycogen to account for their resistance to recurrent anaerobiosis.

Previous reports from this laboratory (Doochin and Smith, 1951, and Isham, Moore and Smith, 1951), have indicated that the dominant local representative of the family Teredinidae is *Teredo (Lyrodus) pedicellata* Quatrefages. This report is concerned with this form alone.

Materials and Methods

Unprotected wooden panels of various convenient sizes were suspended in the water of Biscayne Bay to provide a continuous supply of animals for biochemical study. It was found that these panels afforded animals of useful size after approximately two months exposure. Panels were generally completely destroyed by the end of six months.

For the glycogen studies to be reported here, the panels were removed from the water and returned to the laboratory. It was found that the contained teredids would remain alive over a period of at least twelve hours with no significant change in glycogen content, so long as they were not subjected to extremes of temperature. The panels were split and the individual borers were carefully removed from their burrows intact. It was found that the glycogen content of the evicted borers did not vary significantly during a two-hour period of storage in sea water at 4°C. Thereafter the worms were collected into a small quantity of chilled sea water and maintained at this temperature until they could be used.

Initial quantitative glycogen determinations were made by the official AOAC method. For this portion of the study it was customary to take enough entire animals to make up a sample of from two to 10 grams wet weight. This required from five to 15 borers.

Subsequent glycogen determinations, which were generally made upon single individuals, made use of the trichloroacetic acid extraction method of Van Der Kleij (1951), combined with the very simple but extremely sensitive spectrophotometric method of glucose determination of Mendel and Hoogland (1950). The only modification introduced in this study, was the use of a purified authentic shipworm glycogen sample for the preparation of the calibration curves.

Histochemical localization of glycogen was accomplished by the

method of Best (see Conn and Darrow, 1948). This method has proved to be highly practical and readily controllable in our hands.

Results and Discussion

Results of analyses of groups of *T. pedicellata* are presented in Table 1. Figure 1 shows graphically the changes in glycogen content that occur with growth and maturation. It should be pointed out that the data presented in Figure 1 were secured by analysis of individual worms, while those in Table I were derived from analysis of several animals at the same time. The close agreement between the two sets of data, so far as percent glycogen is concerned, is worthy of comment.

TABLE I

Average Glycogen Content of T. pedicellata

No. of Animals	Av. Wet Weight	% Moisture	Av. Glycogen grams	$\frac{\text{Glycogen}}{\text{Dry Weight}} \times 100$
12	0.937	76.4	0.1285	58.2
14	0.277	66.0	0.0135	14.55
10	0.039	67.0	0.0032	34.75
5	0.342	72.7	0.1632	17.50
9	0.163	76.1	0.0083	21.2
9	0.127	75.8	0.0129	42.2
7	0.173	71.2	0.0190	38.1
				Av.—32.36

The considerable variability which is inherent in these data may indicate an actual variability in glycogen content or, as seems more likely, it may simply reflect varying degrees of glycolysis incident to manipulation of the animals during the sampling procedures.

Having established the existence of very considerable concentrations of glycogen in *T. pedicellata,* its location in the animal was next investigated. An initial survey was conducted in which different regions of the worms were separately analyzed for glycogen. One sample consisted of the gut and its contents, gut derivatives and the gonads from a series of worms. The eviscerated residues of the same animals formed the second sample. The third sample consisted of intact teredids. The glycogen content of the visceral sample averaged 0.12%, the eviscerated residue contained 19.3%, and the intact control worms showed 23.57% glycogen. These results suggested that the chief glycogen depots in the animal were located elsewhere than the viscera.

For more precise localization of the glycogen stores, a series of animals was prepared for histochemical study according to the

method of Best. As might have been suspected from the generally high concentrations of glycogen which characterize *T. pedicellata,* glycogen was found to be very widely and generally distributed through the sections of the animal. Noteworthy among the organs of the body for their extremely high concentrations of discrete particulate glycogen masses were the mantle, muscle tissues, gill and imbedded larvae.

The mantle contributes significantly to the total stores of glycogen contained in the animal. The posterior 80% of the mantle is heavily laden with many moderately large discrete deposits of glycogen. These tend to be concentrated in the neighborhood of the outer mantle epithelium. The most anterior portions of the mantle are devoid of glycogen.

The muscles of the body, particularly those of the shells, the pallets and the siphons, all show considerable concentrations of glycogen. The siphonal musculature is particularly striking because it contains most of the glycogen of the siphon. In general the excurrent siphon contains more glycogen than the incurrent siphon. The musculature of the pallets is one of the two most concentrated storage depots for glycogen in the entire organism. This is suggestive of a high level of activity for these muscles.

The other organ showing an extremely high glycogen content is the gill and imbedded larvae. It should be mentioned that *T. pedicellata* larvae are retained for varying periods of time actually embedded in the tissues of the maternal gill. Here they pass through the late prenatal stages in their development. The gill epithelium surrounding the larvae is heavily laden with intracellular glycogen. This is suggestive of a possible "placental" function for the epithelium. It may be recalled that Hisaw *et al.* (1930) pointed out that deposition of glycogen in the epithelial cells of the primate uterus is one of the earliest maternal responses to implantation of the fertilized ovum. In the gill of *T. pedicellata,* glycogen appears as extremely small but dense deposits between large nuclei that occur regularly along the edges of the gill filaments. The nonciliated portions of the gill filaments contain significantly more glycogen than the rest of the gill.

Among the organs of secondary importance, so far as their content of stored glycogen is concerned, may be mentioned the heart, the epithelial cells of the gut and of the gut diverticula and of the ovary. The glycogen of the ovary occurs as cytoplasmic granules in the

oocytes. These granules appear to increase both in size and in number as the oocyte matures. The epithelial cells of the gut and of the digestive diverticula occasionally exhibit granular incretions of glycogen. The gut content is positive for glycogen as it should be, of course, because of its predominantly polysaccharide nature.

Teredo must obtain its nourishment either from the wood in which it lives, from the water which surrounds it, or from a combination of these two sources. If the water be thought of as providing food materials it must be recalled that water is admitted to the mantle cavity of *Teredo* only through the incurrent siphon whose internal diameter, although variable, rarely exceeds 250 micra. This structural limitation obviously excludes the larger members of the plankton from consideration as possible food sources and serves to focus attention upon the nannoplankton.

If the plankton provides the raw material out of which *Teredo* synthesizes its considerable glycogen reserve, then it would appear that significant modification of the glycogen content could be effected by maintaining *Teredo* in water from which planktonic organisms had been removed.

Sea water was "sterilized" by filtration through a Seitz filter. It was received into sterile containers, was aerated by passing cotton-filtered, acid-washed air through the reservoir, and was then presented continuously to *Teredo*. The wood in which the latter were living had been scraped deeply to remove surface organisms and contaminated surface layers of wood. It was as free of contamination as it could be made. Moreover the sea water was not recirculated; after one passage it was discarded. Seven days survival under these conditions produced no significant change in glycogen content from the control figures.

The reverse of this experiment was next performed, i.e., the borers were provided with plankton-rich water but were denied access to wood. It is known (Lane and Tierney, 1951) that teredids removed from the wood are seriously handicapped, hydrodynamically. However they often survive under these conditions for a period of 10 days. At the end of such a period the glycogen content will be seen to have decreased by an average of 73%.

Results of glycogen determinations of individual *Teredo* appear in Figure 1. It will be noted that the percentage of glycogen is low in the smallest worms which it has been possible to analyze *in toto*. This is in apparent contradiction to the observation that the glycogen

content of larvae still imbedded in the gill is great. However, unpublished observations by Mr. L. B. Isham, and others, from this laboratory, reveal that the larvae of *T. pedicellata* do not appear to feed during the first seventy-two hours of their free-living life. During this time they are very active both in swimming and crawling. Presumably the glycogen reserves which are present in the larvae still imbedded in the gill are used to power these initial free-living activities of the animal. After the young borers are established in wood—which takes place generally within 72 hours of release from the maternal gill—they began actively to feed and to replace their glycogen reserves.

With continued growth in size there is a rapid increase in glycogen content until the adult level of around 30% is reached by the time the worms have achieved a dry weight of 30 milligrams. This weight is frequently gained in six weeks. Thereafter the percentage of glycogen does not vary significantly, so far as our determinations show, throughout the balance of the adult life of the animal. There is no apparent effect of season or of reproductive activity on these figures.

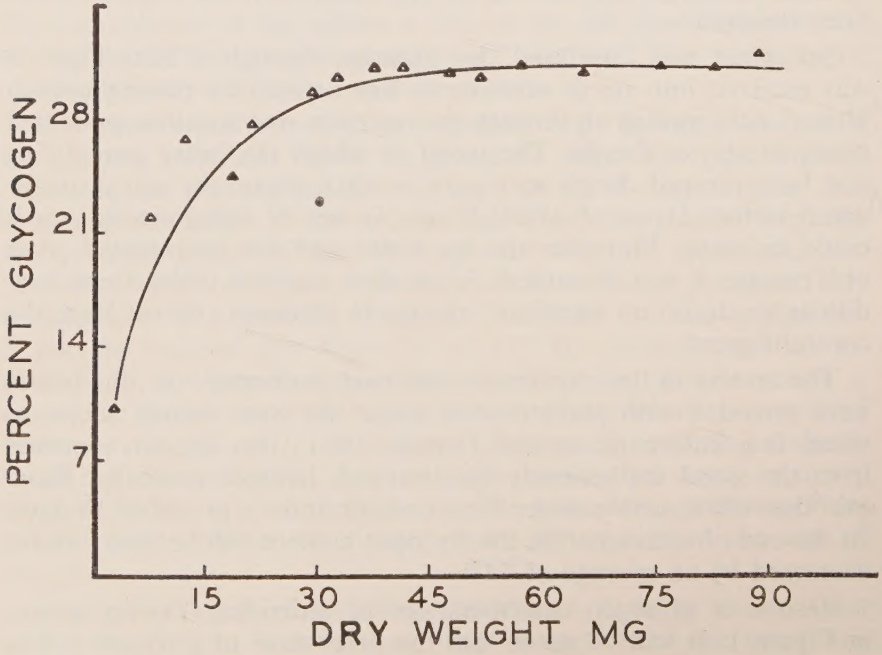

FIGURE 1. Change in glycogen content with development and maturation of individual *T. pedicellata.*

Summary and Conclusions

Adult *Teredo pedicellata* has been shown to contain approximately 30% glycogen on the basis of its dry weight. This figure may be achieved within six weeks after the animal first establishes itself in wood, and it does not show significant variation thereafter.

Most of the glycogen is contained in the mantle, the muscles, and the gills.

Prior to their liberation from the maternal gill, the imbedded larvae contain extremely high concentrations of glycogen.

This prenatal supply of glycogen is largely consumed by the time the larvae have become established as small adults in wood. Glycogen concentration assumed adult magnitude within approximately six weeks.

Teredo maintained in substantially plankton-free sea water for seven days showed no significant change in glycogen content, and when denied access to wood for seven days showed a decrease of 72% in glycogen content.

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GROWTH OF THE AMERICAN OYSTER, *CRASSOSTREA VIRGINICA* (GMELIN) IN FLORIDA WATERS[1]

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The Marine Laboratory, University of Miami

Abstract

Basic growth curves remained the same despite seasonal environmental changes. Oysters setting in the fall had very nearly the same growth pattern as those which attached in the spring. Minor aberrations in all states of growth were encountered in areas of good growing conditions but the fundamental pattern did not differ. Oysters which had been periodically exposed exhibited rapid growth when transferred to places where they remained covered by water at all times. Those which continued to be exposed had a diminished growth rate. Coon bars which exist in Apalachicola Bay support an inferior, small oyster because the individual oysters are exposed at low tide. Extremely long and intensive spawning seasons did not alter the basic growth pattern. Growth was continuous throughout the year. Oysters of Apalachicola Bay which are of low glycogen content and presumably low vigor (possibly induced by rapidly fluctuating salinities) showed remarkably rapid growth rates.

Introduction

An invaluable aid to the biologists working with oysters is the knowledge of rate of growth at various times of the year and at various stages of development. Such information, aside from practical considerations, is interesting because of the extensive distribution of *Crassostrea virginica* (Canada to Campeche). Within this range a great diversity of habitats gives the biologist an opportunity to evaluate the effects of different ecological factors.

Because knowledge concerning growth rate was almost non-existent for Florida oysters, this study was undertaken.

History

Growth of the American oyster has received the attention of several workers, most of whom carried out their investigations in northern waters. A basis of comparison exists, therefore, between growth in Florida and that found to occur in more northerly and cooler habitats. A brief résumé of the studies previously reported is presented in Table I.

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1 Contribution No. 74 from The Marine Laboratory, University of Miami.

TABLE I

SUMMARY OF GROWTH RATE STUDIES ON *Crassostrea virginica* (GMELIN) AND TIME REQUIRED TO PRODUCE EQUIVALENT GROWTH AT APALACHICOLA RATE

Investigator	*Date*	*Place*	*Linear Growth*	*Elapsed Time*	*Growth Period in Apalachicola*
Brice	1896	Tarpon Springs, Fla.	Setting—good sized	10 mos.	.....
Churchill	1921	Long Island Sound	Setting—4-5 in.	4 yrs. (1)	1.4 yrs.(1)
Dean	1892	South Carolina	Marketable size	One season	.....
Glaser	1905	North Carolina	3.4″-4.3″	2 mos.	.....
Glaser	1905	North Carolina	5.2″-5.9″	2 mos.	.....
Glaser	1905	North Carolina	7.2″-7.6″	2 mos.	.....
Gunter	1951	Texas	Setting—3.7″	12 mos.(2)*	28 weeks(2)*
Gunter	1951	Louisiana	Setting—3.1″	10.3 mos.	9 mos.
Higgins	1940	North Carolina	Seed—marketable size	2 yrs.	.....
Higgins	1940	North Carolina	Setting—3″	6 mos.*	4 mos.*
Menzel	1951	Louisiana	Setting—4″	39 wks.*	31 wks.*
Moore	1899	Louisiana	Setting—1″	6 wks.*	5 wks.*
Moore	1899	Louisiana	Setting—3.5″	18 mos.	15 mos.
Moore	1899	Louisiana	Setting—4-6″	23 mos.(1)	17 mos.(1)
Moore	1903	South Carolina	Setting—2.5″	6-7 mos.	6.2 mos.
Moore	1905	South Carolina	Setting—1.5″	2-3 mos.*	7 wks.*
Moore	1905	Long Island	1⅜″-3″	6 mos.*	12 wks.*
Nelson	1922	New Jersey	3.7″-4.2″	12 mos.	6 mos.
Osborn	1883	Beaufort, N. C.	Setting—1″	2 mos.	2 mos.
Ryder	1885	Chesapeake Bay	13/16″	44 days	42 days
Ryder	1885	Chesapeake Bay	1½″	12 mos.	3.5 mos.
Ryder	1885	Chesapeake Bay	3½″	23 mos.	15 mos.
Stafford	1913	Canada	Setting—2″	24 mos.	5 mos.
Winslowt	1913	Chesapeake Bay	Setting—¾″	3 mos.	1.5 mos.

* Maximum growth rate
t *vide* Stafford
(1) Time refers to 4 inches growth
(2) The data of Gunter are not easily compared with Apalachicola findings inasmuch as the oysters he observed were growing under unusual ecological conditions and his samples were small.

Procedure

This study was conducted from May, 1949, until August, 1951, in Apalachicola Bay, present center of the Florida oyster industry. The Bay is approximately 36 miles long and varies in width from about 10 miles to about two miles. The Apalachicola River drains into the Bay and furnishes the fresh water needed for oyster growth. A complete description of the estuary and its hydrography is provided by Ingle and Dawson (1950) and Ingle (1951).

Only linear measurements were used in the investigation. As long as well-shaped, uncrowded individuals were used this was considered a valid procedure and is the one used commonly in the past by other workers. If an oyster was crowded, or in other ways appeared to be abnormal in its proportions, it was not used.

Four different types of experiments were used as described below.

1. Spat growth rate from size at setting to about one inch was studied by using chicken-wire baskets filled with shells. These baskets are the same that are commonly used in the study of spat-fall and are described fully by Loosanoff and Engle (1940). After the baskets were placed in the water oysters adhering to the shells were measured at weekly intervals for six weeks. Only the largest oysters were measured. These presumably had attached soon after the baskets were placed in the water.

2. Older Spat. Growth studies on spat over six weeks of age were made on individuals adhering to cultch planted in widely isolated parts of the Bay. The cultch was planted on June 6, 1949. It consisted of scrap metal, to distinguish it from other substrate. Visits were made to cultch plantings after a lapse of 11, 15, and 16 weeks.

3. Plots, consisting of oysters carefully measured and classified according to size, were planted in Indian Pass and Big Bayou locations known to be favorable for oyster growth. In Big Bayou, planting was made in water deep enough to avoid uncovering at lowest spring tides. The Indian Pass plantings were made in waters which, at low tide, sometimes receded sufficiently to expose the oysters.

4. Trays containing oysters were hung from pilings in four different locations, Indian Pass, Big Bayou, Nick's Hole, and East Slough.

Oysters in trays in Big Bayou and Nick's Hole were unmarked and were placed in trays in groups of similar size. Individual oysters of the East Slough and Indian Pass trays were marked and the growth of each oyster could be followed throughout the experiment.

In order to establish the effect of moving oysters from various

habitats to a central point where all would experience the same, although new, environmental conditions, oysters were secured from several places in Apalachicola Bay and moved into a group of trays in Nick's Hole. These experimental transplantations were made in the fall of 1949 and readings were continued until the spring of 1950. Almost all oysters of this experiment were of known age and had been raised on specially prepared collectors.

The trays at Big Bayou were hung at different depths to determine what effect, if any, could be induced by depth of water.

Observations

The original data are too extensive to publish, but copies are available at the following laboratories:

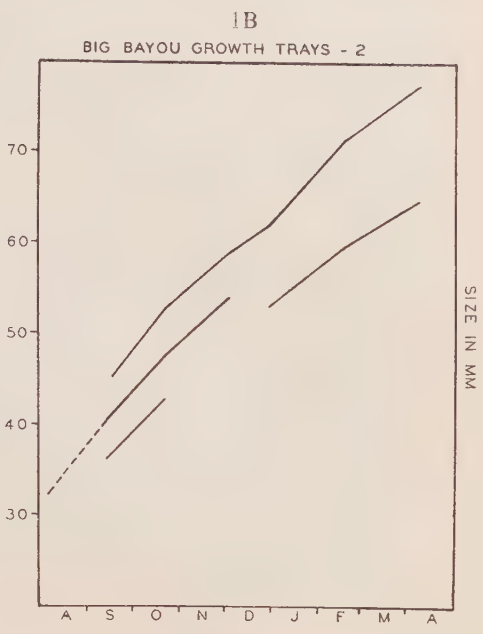
1. Marine Laboratory
   University of Miami
   Coral Gables, Florida
2. Woods Hole Oceanographic Institution
   Woods Hole, Massachusetts
3. Scripps Institute of Oceanography
   La Jolla, California
4. School of Fisheries Biology
   University of Washington
   Seattle, Washington
5. Institute of Marine Science
   Port Aransas, Texas

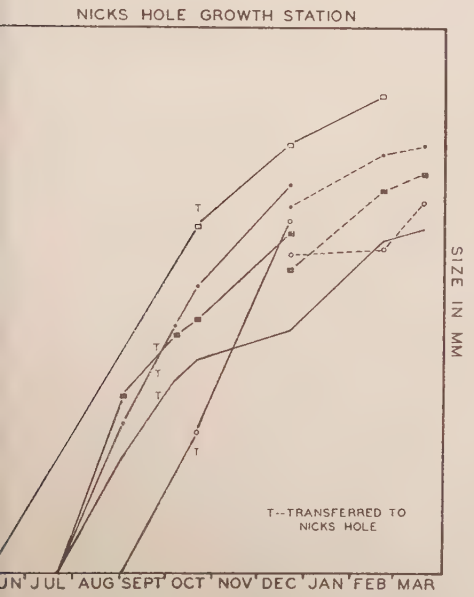
Growth of the various size groups is presented in Figures 1 - 4.

Figure 5 shows the absolute increment per week of oysters from setting to 115 mm. in length, and was prepared by combining all data from each experiment. Figures 6 - 7 give representative hydrographic data from two of the stations studied, Indian Pass and East Slough.

Spat. Data on growth of the youngest spat, up to six weeks of post-larval life, are summarized in Table II. It can be seen that growth equalling that attained in one year in northern waters is reached approximately by Florida's fastest growing oysters by the fifth week of life. The maximum growth at all stages of development has been reported previously by Ingle (1950).

In order to minimize any unusually rapid or slow growth which might have affected the findings, the greatest, the medium, and the smallest of the three largest spat were averaged. The increases were regular in all of these categories.





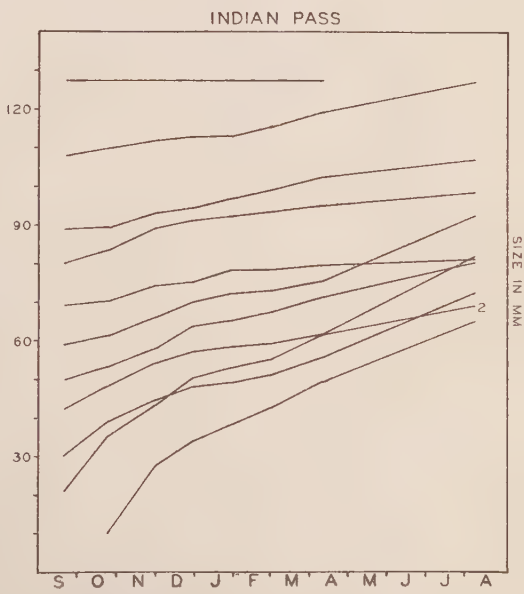


FIGURE 1. Growth of oysters in Big Bayou trays.

FIGURE 2. Growth of groups of oysters setting on special collectors in different parts of Apalachicola Bay. Symbol T indicates time of transfer to Nick's Hole. Dotted lines indicate that several small oysters were added to group, lowering average.

FIGURE 3. Growth of oysters at Indian Pass.

TABLE II

GROWTH OF SPAT IN MM. DURING FIRST SIX WEEKS

	1 Week	2 Weeks	3 Weeks	4 Weeks	5 Weeks	6 Weeks
Largest	4.50	8.0	11.7	21.0	29.9	34.1P*
Medium	4.02	7.9	11.2	18.3	27.3	32.7E
Smallest	3.66	6.8	10.2	17.4	26.6	32.2PB
Average	3.9	7.5	11.0	18.9	27.2	33.0

E, East Slough; P, Pilot's Cove; PB, Porter's Bar.
* A reading of 35.5 reported from cultch in same area.

An average length of 1.29 inches is reached by the end of the sixth week.

OLDER SPAT adhering to cultch were measured at 11, 15, and 16 weeks. As might be expected, great variations existed. For each growing period the three largest oysters were measured out of many tongings from each of seven widely isolated areas of Apalachicola Bay.

Although there were nine stations, all of the data contained in Table III were obtained from the three best locations: Cabbage Lump, Pilot's Cove, and Goose Island.

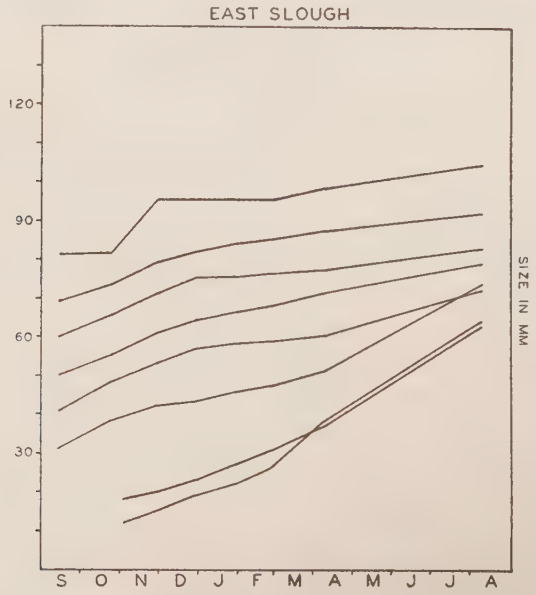


FIGURE 4. Growth of oysters at East Slough.

TABLE III

GROWTH ATTAINED BY SPAT IN MM. ELEVEN, FIFTEEN, AND SIXTEEN WEEKS OF AGE

Weeks	Smallest	Medium	Largest	Average
11	36.8	37.8	47.1	40.6
15	57.2	60.7	62.4	59.6
16	64.1	66.5	68.1	66.2

ADULTS (PLOTS). Originally, four plots of seed oysters were planted in Big Bayou. Two of these were accidentally disturbed by fishermen and the results were discarded. Three plots were established in Indian Pass Lagoon, one of which was disturbed and abandoned. When oysters were measured a second time, difficulty was encountered in locating all of the individuals due to muddy water. It is believed that most of the oysters that were not checked during the second measurement were left on the bottom. The number of dead individuals was very small in each case and no tabulation was made.

Observations made on growth rate plots are summarized in Table IV.

TABLE IV

PLOTS

Plot No.	Size Range mm.	No. Exam.	Date	Time Interval Days	Av. Length mm.	Av. Gain mm.	Weekly Gain mm.
			Big Bayou				
1.	50-82	167	iv-22-49	..	67.8	...	..
	67-98	76	vii-19-49	88	76.0	11.2	0.8
4.	64-100	132	iv-22-49	..	79.0	...	..
	71-111	88	vii-19-49	88	87.6	8.0	0.6
			Indian Pass Lagoon				
1.	49-65	212	iv-28-49	..	60.6	...	..
	57-81	107	vii-21-49	84	65.5	5.5	0.4
2.	66-85	270	iv-28-49	..	60.6	...	..
	66-93	96	vii-21-49	84	78.0	1.8	0.1

ADULTS (TRAYS). Tables showing the growth of oysters in trays cannot be provided here but are on file as indicated previously. A brief discussion of this growth follows:

Oysters were placed in trays in Big Bayou in two groups, Unit 1 and Unit 2, on July 8 and August 5, 1949, respectively. These trays were put in Big Bayou, an area known to be a fine growing area, in

order that some index of growth under optimum conditions might be established. During the second week of September these Units were broken up into smaller groups and replaced in baskets, variously located with regard to depth, attachment to piling, and exposure to light. The new, smaller groups were numbered as to tray and the growth data were itemized separately.

Oysters averaging 32.4 mm. had a summer weekly increment of 1.4 mm. Slightly larger oysters, averaging 65.3 mm., had a weekly increment of only 0.9 mm., during the same period (July 8 - Sept. 9).

Oysters in trays hung in Big Bayou showed a slightly faster rate of growth than those in other areas. As in the other experiments, younger, smaller oysters grew faster than the older, larger ones.

No appreciable difference in growth was noted due to position of trays with regard to tidal flow, wave action, light, or depth of water. The deepest tray was approximately six feet under mean low tide

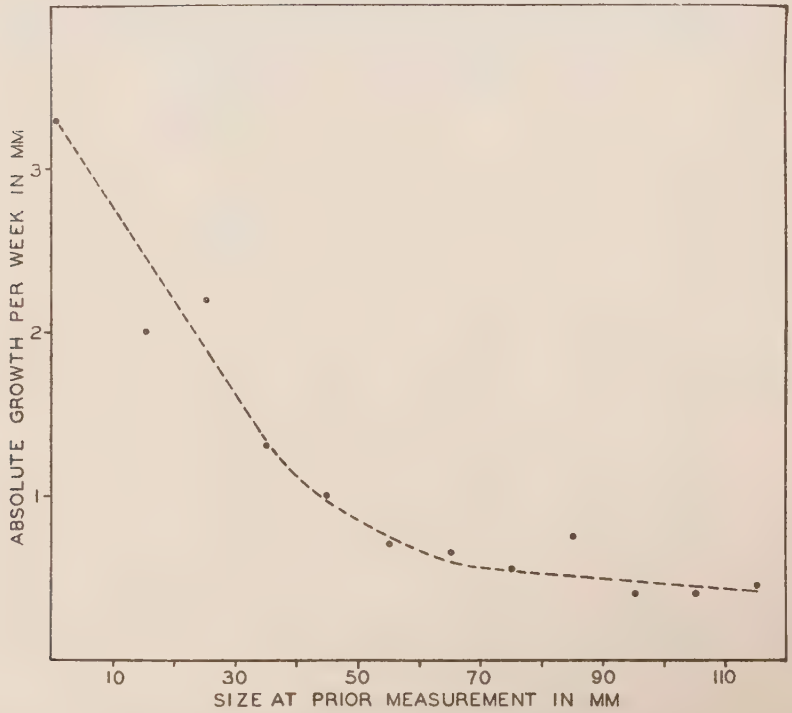


FIGURE 5. Growth per week to be expected for all sizes from setting to 115 mm., prepared by combining all data from each experiment.

and rested on the bottom. The topmost tray had a depth of about one foot at mean low water.

In general all the trays of smaller oysters were more uniform when compared with each other than were the trays holding larger individuals. Also, as might be expected, the smaller oysters in general showed a steeper curve of growth than did the larger.

Discussion

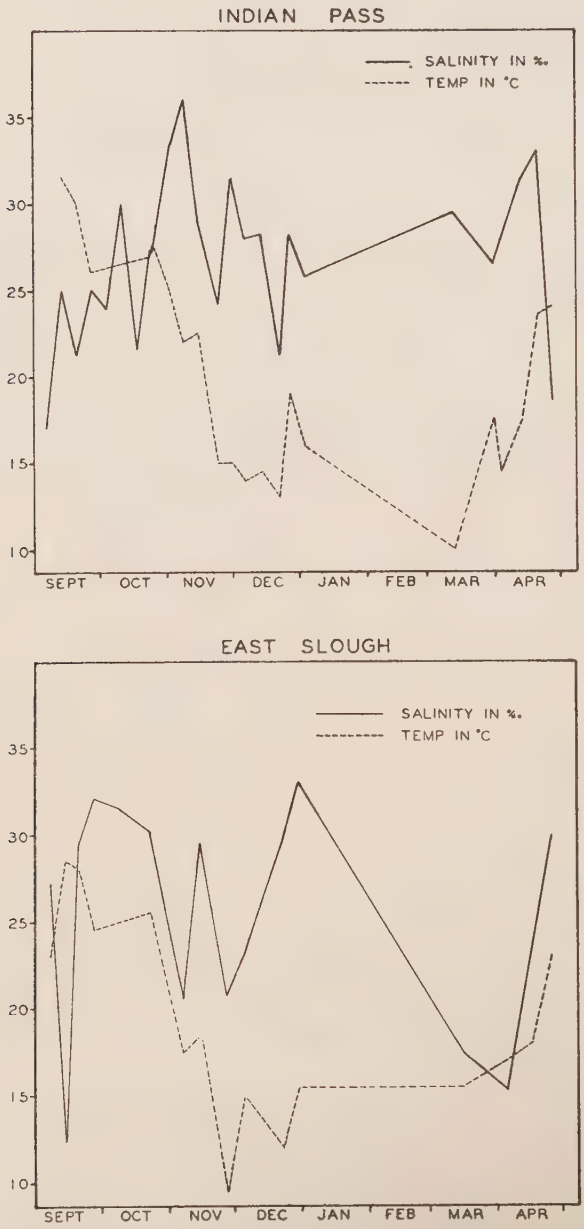
All regions of Apalachicola Bay showed similar growth patterns and approximately the same rate of growth. Oysters in trays hung in Big Bayou showed a slightly faster rate of growth than those of other areas.

It can be seen from Table I that growth of the American oyster in Apalachicola Bay is more rapid than in any other region of its range that has so far been studied. Another important finding is that growth is continuous throughout the year. As shown by Loosanoff and Nomejko (1949), Long Island Sound oysters hibernate during the coldest weather and only grow during the warmer months. They stated, however, that if the temperature of the water is maintained above the hibernation point growth continues.

An explanation for the rapid and extended growth of Apalachicola oysters could possibly be found in the relatively high temperatures of Florida's coastal waters. Much evidence already exists to show that water temperatures are of prime importance in oyster growth. For instance, it has been shown (Loosanoff and Nomejko, 1949) that a reduction of oyster growth ensues when water temperatures drop below 15°C. Their data also showed that growth diminished at 25°C., a finding not duplicated by the present study. The possibility exists that there are physiological races of oysters which exhibit slightly different reactions to environmental conditions. At any rate, the oysters of Apalachicola Bay grew at a high rate, with no evidence of diminution, during long periods when the water temperature was above 25°C. Several times during the study temperatures of 30°C. and higher were recorded.

Loosanoff and Nomejko were also able to bring about a resumption of growth artificially in hibernating oysters by raising the water temperature above the critical point for normal functions.

Although the spawning season has been found to be long and intensive (Ingle, 1950), no noticeable change in rate of growth was induced by gametogenesis, or spawning. This observation is in agree-



FIGURES 6 AND 7. Representative hydrographic data from two of the stations studied.

ment with the conclusions of workers in Milford Harbor, Connecticut (Loosanoff and Nomejko, 1949).

It has been suggested that the rapidly varying salinities found in Apalachicola Bay are at least partly responsible for the relatively low amount of glycogen usually found in the indigenous oysters (Ingle and Dawson, 1950). In any case, neither the vacillating salinity nor low oyster glycogen seem to impair the function of growth; in fact, growth in Apalachicola Bay is the most rapid yet recorded for *C. virginica*. A lack of relationship between oyster vigor and growth has previously been reported (Loosanoff and Nomejko, 1949).

Oyster growth in trays in Big Bayou and Nick's Hole was slightly more rapid than in Indian Pass Lagoon and East Slough. The latter stations were frequently exposed at spring low tides and it is believed that had these oysters been covered at all times, no substantial differences in growth rate would have been noticed. This opinion is supported by the fact that, in general, ecological conditions are practically the same in Nick's Hole and in East Slough. Nevertheless, oysters transferred to Nick's Hole from East Slough grew rapidly while those left behind were slightly retarded.

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MARINE SPECIES OF VAUCHERIA AT BERMUDA[1]

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ABSTRACT

Vaucherias are important elements in the vegetation of the shores and mud-flats of Bermuda. Previously reported species are of the Piloboloideae, and the authors add here another member of that section, *V. nasuta* Taylor and Bernatowicz, n. sp., which combines the sessile beaked oögonium found in certain other sections with the antheridia peculiar to the Piloboloideae, namely, antheridia supported on an empty suffultory cell and discharging through tubular pores. Also reported is *V. dichotoma* (L.) C. Ag., a species with distinctive large spherical oögonia and sessile antheridia on separate plants.

In another paper the authors (1952) have shown how the desire to find out as much as possible about the ill-known *Dichotomosiphon pusillus* Collins (1909), which Collins and Hervey (1917) had reported from the colony, led to the study of other filamentous nonseptate algae of the shores and mudflats of Bermuda. The identification of the species of *Vaucheria* was especially relevant, for that genus is similar to *D. pusillus* in ecological requirements and may grow with it. The proper habitats are common in Bermuda and support the two genera in sufficient luxuriance to make them significant from the point of view of the ecologist. Since the American marine members of *Vaucheria* are not well known, although they are widespread and often abundant on our south and east coasts, descriptions of the Bermuda material seemed appropriate. We wish to discuss here two species hitherto unreported from Bermuda, one of which, we believe, has not previously been recognized.

It is exceedingly curious that of the five species of *Vaucheria* now known from Bermuda, four belong to the section Piloboloideae, even though that section is chiefly composed of marine species, for there is seldom a great variety in any limited area. Collins and Hervey (1917) reported *V. sphaerospora* Nordst.; we have elsewhere reported *V. piloboloides* and *V. bermudensis,* and we add *V. nasuta* at this time. The other species, *V. dichotoma,* is of the section Woroninia and is totally unlike the rest. We do not expect that our present collections will yield additions to this list.

This work was facilitated by a grant from funds placed at the dis-

1 Contribution No. 953 from the Department of Botany, University of Michigan, and No. 176 from the Bermuda Biological Station.

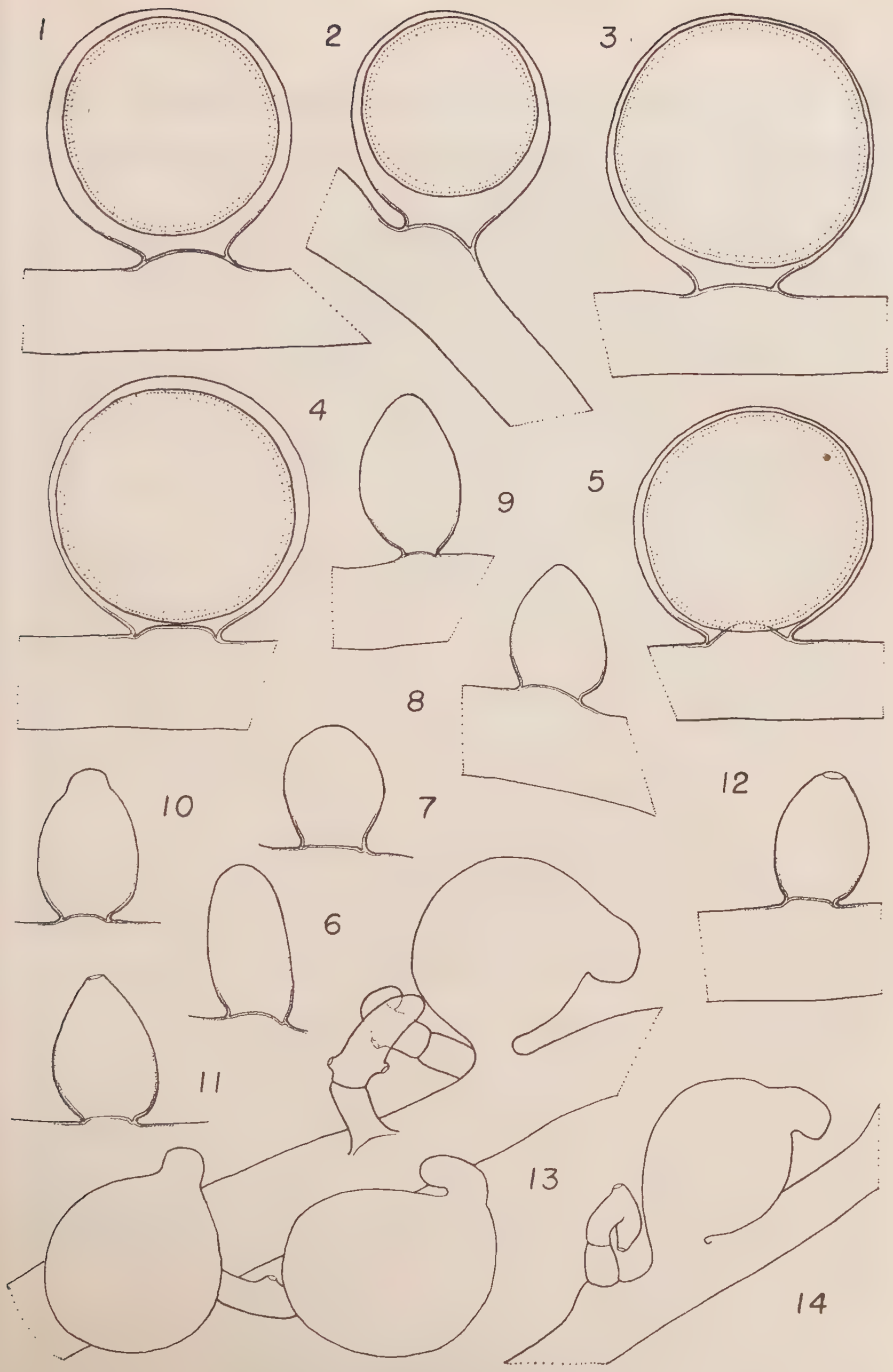
posal of the Bermuda Biological Station for Research, Inc. by the American Philosophical Society, and subsequent funds similarly supplied to the senior author directly. For this generous aid, and for the very cordial coöperation of the former Director of the Bermuda Biological Station, Dr. D. E. S. Brown, and its present Director, Dr. Louis Hutchins, the writers are exceedingly grateful.

Vaucheria dichotoma (L.) C. Ag.—Filaments coarse, dichotomously branched, 80-225 μ, commonly 100-135 μ diam., occasionally the wall brownish; dioecious, the antheridia usually several together, irregularly or, more commonly, unilaterally disposed in a series along the filament, sessile, erect or a little oblique, oval to ovoid with a slightly pointed apex, 100-144 μ diam., averaging 128 μ, and 137-225 μ long, averaging 181 μ. Oögonia solitary or a few together, subseriate and unilateral, sessile, erect, subspherical to obovoid, 260-360 μ diam., averaging 316 μ, 280-380 μ long, averaging 322 μ. Oöspores nearly spherical, free in the oögonia and nearly filling them, 210-340 μ diam., averaging 289 μ, with a very slightly thickened brown wall. Plate I, Figs. 1-12.

In habit, *V. dichotoma* forms a pilose expanse of coarse, erect, dark green filaments 3-4 centimeters high which are connected by a system of equally coarse buried filaments.

The Bermudian specimens here described come within the dimensions prescribed for *V. dichotoma,* or at least the *f. marina* Hauck (1885), if one wishes to maintain the distinction. The filaments do not reach the maximum diameters recorded (Børgesen, 1913; Collins, 1909; Heering, 1921), nor the oögonia, oöspores and antheridia the greatest dimensions, but the differences are slight and, considering the small number of collections, the agreement may be considered excellent. The antheridial length given by Brown (1929) of 332 μ is probably an error for 232 μ, since in other respects her data correspond to those of Heering (1921), and no source for this quite aberrant figure is given.

In our material the oögonia seem quite sessile (Plate I, Figs. 1-5). The oöspores usually fill the oögonia (Plate I, Figs. 4, 5), but occasionally a little space is left near the base (Plate I, Figs. 1-3), which in extreme cases causes the shape to be slightly pyriform. The antheridia are likewise sessile and most characteristically form long erect series on the male filaments. At first they are more or less oval (Plate I, Figs. 6, 7), but as they mature they become more pointed above and the tip may even be drawn out a little (Plate I, Figs. 8-10). After



EXPLANATION OF PLATE I

Vaucheria dichotoma

FIGURES 1-5 Mature oögonia with oöspores
FIGURES 6, 7 Young antheridia
FIGURES 8-10 Mature antheridia before dehiscence
FIGURES 11, 12 Antheridia after dehiscence

Vaucheria nasuta

FIGURES 13, 14 Portions of filaments showing both oögonia and antheridia
(Figures 1-12, x 96; Figures 13, 14, x 190)

shedding they retain the pointed ovoid shape, showing the discharge pore at the apex (Plate I, Figs. 11, 12).

There is every reason to believe that our Bermudian plant is the same as that which is well known from Europe (Heering, 1921) and from several stations in America (Prescott, 1938), and which is reliably reported from the West Indies (Børgesen, 1913), but not at all from Bermuda. Its absence from previous records of Bermuda algae is probably due to failure to find determinable, *i.e.*, fruiting, material, for we found it conspicuous in bays which were explored by Collins and Hervey (1917), Howe (1918), and Rendle (1936). Fruiting does not seem seasonally restricted since we collected fertile specimens in April, August, and December.

Because of its coarse filaments, even in the field *V. dichotoma* is recognizably different from *V. bermudensis* and *V. piloboloides,* which inhabit almost similar situations. Although the three species inhabit quiet areas, *V. dichotoma* was not seen by us where it might be exposed to occasional waves driven into a bay by storms. Rather, we found it in parts of bays which do not face the open sea. Most of the colonies of *V. bermudensis* and *V. piloboloides* were not equally protected on all sides. In substratum and tidal relationships the three species were similar. The substratum was either mud or sand, the latter sometimes so infiltrated with black, finely-divided organic matter that it appeared to be a gritty mud. Portions of the colonies were laid bare briefly at almost every low tide, and probably no parts of a colony were immersed during low water spring tides. Clearly, *V. dichotoma* is a marine species at Bermuda, though known from fresh-water stations elsewhere.

BERMUDA: St. Georges I., north side, on sand near low tide level at Coot Pond (salt), coll. Bernatowicz *No. 49-2093*, 20 Aug. 1949. *Ibid.,* south side, 1 dm. below tide level on sand at the west lobe of Mullet Bay, coll. Bernatowicz *No. 49-2108*, 21 Aug. 1949. Hamilton I., south side, on mud for 1.5 dm. above and below low tide level, with abundant *Penicillus* in a cove on the east side of Hungry Bay, coll. Bernatowicz *No. 50-417,* 7 Dec. 1950. *Ibid.,* northwest end, on sand about low tide level at Fairylands, coll. Taylor and Bernatowicz *No. 49-670,* 8 April 1949.

Vaucheria nasuta Taylor and Bernatowicz *n. sp.*—Filaments forming a mat on the substratum, 28-65 μ, generally about 45 μ diam., forking dichotomously and branching laterally at wide angles. Monoecious, the oögonia solitary or two to three together, the antheridia

scattered, or several near the oögonia. Antheridia one-celled, stipitate, the stalk usually consisting of a thin-walled hyaline supporting cell tapering a little toward its base, the average diameter at the distal end 22 μ, and the length 25-65 μ, averaging 41 μ, straight or, more generally, curved and itself sometimes borne on a short protuberance from the filament. Antheridial cells cylindrical to narrowly oval or obovate, seldom straight, generally curved and often closely so, tapering a little at the ends, 17-28 μ diam. at the base, 50-115 μ in axial length, averaging 22 μ x 81 μ, emptying terminally or by 1-4 lateral, plane to tubular discharge pores. Oögonia sessile or subsessile, oblique to nearly parallel to the filament, subspherical to oval, asymmetrically attached, with a deflexed beak about 15-25 μ in diameter and somewhat longer (measured on the under or short side). Oöspores nearly filling the oögonium, subspherical to oval, 80-140 μ diam., 80-156 μ long, averaging 115 μ x 124 μ, with a brown slightly roughened wall about 3 μ thick.

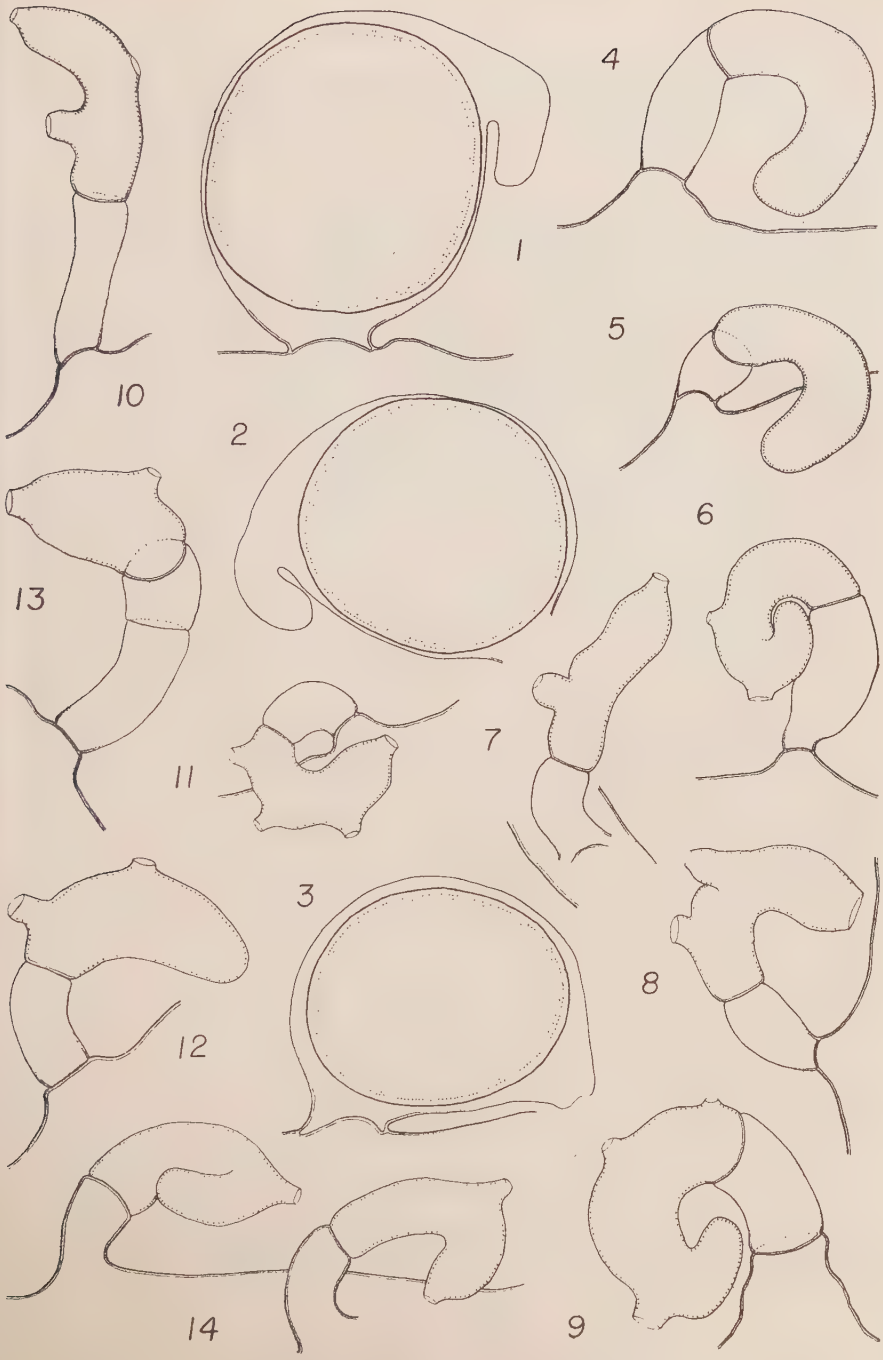
Vaucheria nasuta Taylor and Bernatowicz, *n. sp.*—Filamenta tegetem c. 45 μ diam. in substrato formantia, furcatio dichotoma, ramificatio lateralis, angulis latis. Planta monoecia, oogoniis solitariis vel binis trinisve, antheridiis plerumque prope oogonia sitis. Antheridia unicellularia, stipitata, stipes e cellula sustinente hyalina, membranam tenuem habente, constans. Cellulae antheridii cylindricae ad ovates obovatasve, plerumque curvatae, ad extremitates paululum attenuatae, in basi 17-28 μ diam., in longitudine axiali 50-115 μ, per 1-4 poros emittentes. Oogonia sessilis, obliqua aut subparallela ad filamentum, subsphaerica ad ovata, rostro deflexo praedita. Oosporae oogonium fere complentes, subsphaericae ad ovatas, 80-140 μ diam., 80-156 μ long., membranam brunneam subasperatam c. 3 μ crass., habentes. Specimen typicum in loco dicto Emily Bay, St. Davids I., Bermuda, legit. A. J. Bernatowicz *No. 51-862,* 5 Feb. 1951.

This *Vaucheria* combines the beaked oögonia of *V. aversa, V. synandra, and V. pachyderma* (Heering, 1921) with antheridia more nearly similar to those of the Piloboloideae. *Vaucheria synandra* has a peculiar androphore, in which a hyaline supporting cell bears a large swollen central cell to which several curved antheridia are attached, and so it is similar to *V. nasuta* only in the possession of a supporting cell. The antheridia of *V. aversa* and *V. pachyderma* are not generally considered to have such a cell, although Prescott (1951, Plate 66, Figs. 9, 10) does suggest that *V. aversa* may occasionally have one. The antherida of *V. nasuta* when strongly curved markedly

resemble those of several Vaucherias, especially when, as occasionally happens, the supporting cell is not cut off, but the hyaline stalk cell and tubular discharge pores of the new species are certainly like those of the Piloboloideae. Other resemblances to Piloboloideae are at the species level. For example, the free oöspores resemble those of *V. coronata* and *V. longicaulis* (Heering, 1921; Hoppaugh, 1930) more than the anchored spores of *V. piloboloides* and *V. bermudensis* (Taylor and Bernatowicz, 1952), while the position of the antheridia, *i. e.,* independent of the oögonia, is strikingly different from the close association seen in *V. coronata* and *V. intermedia* (Heering, 1921). Since the beaked oögonium is a character already reported in three sections of the genus, it seems that the hyaline cell supporting the antheridium should be the determining character and this species should be referred to the section Piloboloideae, even though no beaked species has hitherto been reported.

The antheridia and oögonia of *Vaucheria nasuta* are found close together on the filaments (Plate I, Figs. 13, 14). The sessile, beaked oögonia are moderately large (Plate II, Figs. 1-3). The antheridia are generally borne on a hyaline stalk cell (Plate II, Figs. 4-12) which itself sometimes crowns a slight eminence on the filament (Plate II, Figs. 4, 9) though this is generally less perceptible (Plate II, Figs. 10, 13). Not infrequently the stalk is not cut off from the filament by a basal wall and then remains green (Plate II, Fig. 14). Other anomalies are rare, but elongation of the hyaline cell (moderate in Plate II, Fig. 10) is sometimes considerable, and this cell is even seen in a divided state (Plate II, Fig. 13). The degree of curvature varies greatly, from nearly straight (Plate II, Fig. 7) to more than a complete circle (Plate II, Fig. 6). The number of lateral discharge pores varies from one to four at least, probably two being the most common number. The elongation of the membrane about the pore into a tube is seldom marked, the condition seen in Plate II, Fig. 9 being about average, while that seen in Plate II, Figs. 7, 8 and 12 is less frequent.

Inhabiting shaded portions of well-protected bays, *Vaucheria nasuta* grows high in the intertidal region, reaching high water mark on the one side and descending to mid-tide or a bit lower on the other. Below it, *Enteromorpha* and *Cladophoropsis* are to be expected. At the level of *Vaucheria* one may find more or less *Bostrychia*, especially if some rock is available, or some wisps of *Rhizoclonium*. If present in the vicinity at all, *Monostroma* is usually also at this level. Above



EXPLANATION OF PLATE II

Vaucheria nasuta

FIGURES 1-3 Mature oögonia with oöspores
FIGURES 4, 5 Mature antheridia before dehiscence
FIGURES 6-12 Mature antheridia after dehiscence
FIGURE 13 Mature antheridium with two complete hyaline stalk cells
FIGURE 14 Two mature antheridia on a filament, the stalks not cut off by any basal wall

(Figures 1-3, x 290; Figures 7, 10-13, x 365; all others, x 405)

Vaucheria there is often *Rhizoclonium* and sometimes *Dichotomosiphon.*

In habit of growth, this *Vaucheria* fashions mats which are small and pad-like if occupying pockets of mud in crevices of the shore rock, but which more commonly are extensive plush-like growths on gently sloping mud banks. In the latter case the mats are similar to the velutinous coatings of intertidal species of *Vaucheria* of New England and are almost indistinguishable from stands of *Dichotomosiphon pusillus* in Bermuda. Indeed, *Vaucheria nasuta* was distinguished from *Dichotomosiphon* in the field only when the two occupied adjacent zones. Under such direct comparison *Vaucheria* was seen to be lighter in color and to have a slightly longer pile, although the erect filaments forming the pile were only a few millimeters high.

Very often, intertidal species of *Vaucheria, e. g., V. Thuretti* and *V. compacta* as well as *V. nasuta,* are found in situations where mud is the only substratum present. It is then difficult to decide whether the correlation of *Vaucheria* and mud indicates a dependence of the plant on the substratum, or whether the correlation is due to other environmental factors which permit the growth of *Vaucheria* at the same time that they cause the deposit of mud. It was observed that at Hungry Bay areas of sand occur under mangroves beside areas of mud and at no discernible difference in level, yet there was no *Vaucheria* on the sand while the mud was covered by *V. nasuta.* At Hungry Bay, then, it appears that mud plays an active role in determining the presence of *Vaucheria nasuta* and is not a mere concomitant, although rigorous proof is wanting.

BERMUDA: St. Davids I., north side, on pockets of mud on rocks about high tide level with *Bostrychia* along the west shore of Emily Bay, coll. Bernatowicz *No. 51-862* (TYPE), 5 Feb. 1951. St. Georges I., south side, abundant under mangroves in a cove just east of Shore Hills (the Biological Station property), coll. Bernatowicz *No. 51-631,* 8 Jan. 1951. Hamilton I., south side, abundant on muddy bank of the tidal creek at Hungry Bay, coll. Bernatowicz *No. 49-1595,* 6 May 1949. *Ibid.,* abundant on mud under the mangroves bordering part of the bay, coll. Bernatowicz *No. 51-865,* 6 Feb. 1951.

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A PRELIMINARY REVIEW OF THE WESTERN NORTH ATLANTIC FISHES OF THE GENUS *HAEMULON*[1]

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ABSTRACT

The genus *Haemulon* is subjected to a preliminary revision partially on the basis of material in the collection of the Marine Laboratory, University of Miami, which has not hitherto been examined. Revised diagnosis and description are given for the species, *flavolineatum, parra, sciurus, plumieri, album, melanurum, steindachneri, macrostomum, bonariense* and *carbonarium*. A key and tabulation of the more important taxonomic characteristics are included.

INTRODUCTION

The published material on fishes of the genus Haemulon is scattered among several papers, none of which gives the reader a satisfactory means of identifying species. Some of the older keys, although in current use, offer many difficulties to the ichthyologist. This is due both to the insufficient number of characters observed and to the insufficient number of fish examined. Despite the importance of this group of fishes to commercial and sport interests, no adequate key to their identification exists.

The present account includes a key in which many obvious and important taxonomic characters heretofore overlooked or entirely ignored are used, together with a diagnosis and a description of each species in the genus as a further aid to identification. A thorough revision of the group is not intended. Further study on material collected from widely separated points is needed in order to understand the genus fully.

The data presented herein were obtained mostly from material in the reference museum of the Marine Laboratory, University of Miami and from the United States National Museum. Thanks are due to the officers of these institutions for their kindness in allowing use of the collections for study. I am grateful to Professor Luis Rene Rivas for his help in preparing this paper and for allowing me the use of unpublished data on Western Atlantic *Haemulon*.

METHODS

Measurements were expressed as the number of times a given part was contained in the standard length, measured from the tip of the

1 Contribution No. 78 from Marine Laboratory, University of Miami.
2 Present address: Box 984, Hollywood, Florida.

snout (anterior tip of the upper lip) to the caudal base, in the head length, from the tip of the snout to the extreme fleshy margin of the opercle or in other base lengths such as the snout, maxillary, and least depth of the caudal peduncle. The snout was measured between the tip of the upper lip and the anterior margin of the orbit. The postorbital distance was measured between the posterior fleshy margin of the orbit and the extreme fleshy margin of the opercle. The ventral length was measured between the origins of the pelvic and anal fins. The predorsal lengths were taken from between the tip of the snout to the origin of the spinous and soft parts of the dorsal fin. The postdorsal lengths were measured from the origins of the spinous and soft parts of the dorsal fin to the caudal base. Lengths of all fins were measured from their origins to their most distal parts. Preanal, prepectoral and prepelvic lengths were measured between the tip of the upper lip and the origins of the respective fins. Postanal, postpectoral and postpelvic lengths were measured between the origins of the respective fins and the caudal base. The upper length of the caudal peduncle was measured between the insertion of the dorsal fin and the caudal base; the lower length of the caudal peduncle was measured between the insertion of the anal fin and the caudal base. All measurements were made and stepped off with fine-pointed dividers.

The last ray of the dorsal and anal fins was considered as a double ray split to the base. All pectoral rays were counted as single rays. The scales counted along the lateral line from the upper end of the opercular margin to the caudal base were those bearing pores and were smaller than the adjoining scales. The scales counted above the lateral line from the origin of the first dorsal spine to the lateral line were in a vertical series. Other measurements and counts used in this paper are self-explanatory. All fishes examined were preserved material.

Genus *Haemulon* Cuvier

The following abbreviated diagnosis characterizes the genus *Haemulon.*

Body oblong, usually more or less elevated; mouth wide, the maxillary long and curved, reaching to below the eye; chin with a central groove behind the symphysis; lower jaw included; gill rakers moderate; no teeth on vomer or palatines; teeth of the jaw conical, the outer series stronger, curved; lips and inside of mouth posteriorly commonly bright with red or scarlet in life; preopercle serrate, with no recurved hooks below; soft parts of the vertical fins completely covered with scales; scales about the lateral line in series not parallel with lateral line; a marked angle formed at the junction of the spinous and

soft parts of the dorsal; second anal spine enlarged, generally larger and longer than the third; caudal forked.

The Genus *Haemulon* is one of the 13 genera of the family Haemulonidae, which contains about 150 species. The family is close to the Lutianidae on one hand and to the Sparidae and Sciaenidae on the other. *Haemulon* is closely related to *Bathystoma* and *Anisotremus*. *Bathystoma* differs mainly in having an additional dorsal spine and smaller scales while *Anisotremus* differs in having a smaller mouth and a lunate caudal fin. *Lythrulon* and *Orthostoechus* are also quite close to *Haemulon*.

KEY TO THE WESTERN NORTH ATLANTIC SPECIES OF *HAEMULON*

1a. Scales below lateral line on pectoral region enlarged.
1. *H. flavolineatum*

1b. Scales below lateral line on pectoral region not enlarged.
2a. Pectoral fin entirely covered with scales except along edge.
2. *H. parra*

2b. Pectoral fin not covered with scales except basally.
3a. Horizontal stripes on head and body, about 9 or 10 (see also 3c).
3. *H. sciurus*

3b. Horizontal stripes on head only, about 12 (see also 3c).
4. *H. plumieri*

3c. Stripes on head and/or body, if present; not horizontal.
4a. Eye 4.8 to 7.7 in head. No elongate black blotch beneath free margin of preopercle at angle.
5. *H. album*

4b. Eye 2.3 to 4.7 in head. Elongate black blotch beneath free margin of preopercle at angle.
5a. Maxillary reaching to vertical from center of eye or beyond. Preopercular serrae free, conspicuous, projecting beyond membranous border of preopercle.
6a. Dorsal fin XII, 17 or 18. Pectoral fin length 4.2 to 4.5 in standard length. Origin of dorsal fin to origin of pectoral fin 4.6 to 5.0 in standard length. Back with a well defined dark area extending from first dorsal spine to base of caudal and covering lower half of soft dorsal and middle of caudal lobes.
6. *H. melanurum*

6b. Dorsal fin XII, 15. Pectoral fin length about 3.8 in standard length. Origin of dorsal fin to origin of pectoral fin 4.1 to 4.3 in standard length. Back without a dark area.
7. *H. steindachneri*

5b. Maxillary not reaching to vertical from center of eye. Preopercular serrae embedded in membranous border of preopercle.
7a. Scales 7 or 8 above lateral line. Gill rakers 26 to 29 on first arch. Maxillary 5.5 to 6.1 in standard length.
8. *H. macrostomum*

7b. Scales 5 or 6 above lateral line. Gill rakers 21 to 24 on first arch. Maxillary 6.3 to 7.3 in standard length.
8a. First predorsal length 2.1 or 2.2 in standard length. Least depth of caudal peduncle 8.0 to 9.2 in standard length.

Sides of body with oblique, wavy stripes which are sometimes forked.

9. *H. bonariense*

8b. First predorsal length about 2.4 in standard length. Least depth of caudal peduncle 9.4 to 10.0 in standard length. No stripes on sides of body.

10. *H. carbonarium*

1. *Haemulon melanurum* (Linnaeus)
French margatefish; Caesar; Jeniguano

Perca marina cauda nigra (black tail) Catesby, 1743 (Bahamas), pl. 7, fig. 2.
Perca melanura Linnaeus, 1758: 292 (Bahamas; based on Catesby).
Haemulon schranki Agassiz *in* Spix, 1831: 131 (Brazil), pl. 69a.
Haemulon dorsale Poey, 1860a: 179 (Cuba).
Haemulon melanurum Cope, 1871: 471; Jordan and Swain, 1885: 300; Jordan and Evermann, 1898: 1302-1303 (description; synonymy; Havana).

Diagnosis: Dorsal fin XII, 17 or 18. Gill rakers 22 or 23 on first arch. Scales 7 or 8 above lateral line. Origin of dorsal fin to origin of pectoral fin 4.6 to 5.0 in standard length. Least depth of caudal peduncle 9.1 to 10.2 in standard length. First predorsal length 2.4 or 2.5 in standard length. Diameter of orbit 3.4 to 4.1 in head. Length of pectoral fin 4.2 to 4.5 in standard length. Pectoral fin not covered with scales, except basally. Elongate black blotch beneath free margin of preopercular angle. No horizontal stripes on head or body. Scales below lateral line on pectoral region not enlarged. Maxillary reaching to vertical from center of eye or beyond. Preopercular serrae free, conspicuous, projecting beyond membranous border of preopercle.

Description: Dorsal fin XII, 17 or 18; anal fin III, 8 or 9; pectoral fin rays 16 or 17; caudal fin branched rays 15. Scales 49 to 51 along lateral line, 7 or 8 above lateral line. Gill rakers 13 or 14 on lower limb of first arch, 8 or 9 on upper limb of first arch. Vertebrae 26, including the hypural.

Head 2.7 to 3.0 in standard length. End of head to caudal base 1.4 to 1.6 in standard length. Snout 6.9 to 8.3 in standard length. Maxillary 5.5 to 6.4 in standard length. End of maxillary to origin of pectoral fin 4.3 to 5.1 in standard length. Diameter of orbit 3.4 to 4.1 in head, 1.2 to 1.6 in snout, 1.7 to 2.0 in maxillary, 1.0 to 1.3 in least depth of caudal peduncle. Postorbital length 6.9 to 7.5 in standard length. Ventral length 3.1 to 3.4 in standard length. Greatest depth of body 2.9 to 3.1 in standard length. Spinous dorsal base 2.8 to 3.1 in standard length; soft dorsal base 4.2 to 5.2 in standard length; total dorsal base 1.7 to 2.0 in standard length. First predorsal length 2.4 or 2.5 in standard length; second predorsal length 1.4 or 1.5 in stan-

dard length. First postdorsal length 1.4 to 1.6 in standard length; second postdorsal length 2.7 to 3.0 in standard length. Origin of dorsal fin to origin of pectoral fin 4.6 to 5.0 in standard length, to origin of anal fin 2.0 or 2.1 in standard length. Length of soft dorsal fin 3.7 to 4.1 in standard length. Origin of soft dorsal fin to origin of pectoral fin 2.4 to 2.7 in standard length, to origin of pelvic fin 2.3 to 2.6 in standard length, to origin of anal fin 3.1 to 3.6 in standard length. End of soft dorsal fin to end of anal fin 7.0 or 7.1 in standard length. Length of anal fin 4.8 to 5.0 in standard length. Preanal length about 1.4 in standard length; postanal length 3.0 to 3.2 in standard length. Anal base 6.8 to 7.5 in standard length. Length of pectoral fin 4.2 to 4.5 in standard length. Prepectoral length 2.7 to 2.9 in standard length; postpectoral length 1.4 to 1.6 in standard length. Origin of pectoral fin to origin of pelvic fin 6.1 to 6.9 in standard length, to origin of anal fin 2.5 to 2.7 in standard length. Length of pelvic fin 4.5 to 4.7 in standard length. Prepelvic length 2.2 to 2.7 in standard length; postpelvic length 1.5 to 1.7 in standard length. Upper length of caudal peduncle 6.0 to 7.1 in standard length; lower length of caudal peduncle 5.1 to 5.4 in standard length. Least depth of caudal peduncle 9.1 to 10.2 in standard length. Upper caudal lobe 3.6 to 4.5 in standard length; lower caudal lobe 4.0 to 4.4 in standard length. Length of middle caudal rays 6.5 to 8.2 in standard length.

Six specimens were examined ranging from 91 to 138 mm., standard length.

Although this species varies in color, it is often bluish-silvery with about nine longitudinal golden stripes on head and sides.

The range of this species is from South Florida through the West Indies, Panama and southward to Brazil. It is not very common north of Havana, Cuba.

2. *Haemulon macrostomum* Gunther
Spanish grunt; Gray grunt; Striped grunt; Ronco

Haemulon macrostoma Gunther, 1859: 308 (Jamaica).
Haemulon fremebundum Goode and Bean, 1879: 340 (Clearwater Harbor, Florida).
Diabasis fremebundus Jordan and Gilbert, 1883: 554.
Haemulon macrostomum Jordan and Evermann, 1898: 1296-1297 (description; synonymy; Key West, Florida).
Haemulon chrysopterum Mowbray (not of Cuvier and Valenciennes), 1915: 1298 (figures; Key West, Florida).
Haemulon mowbrayi Jordan and Evermann, 1927: 505 (Key West, Florida).

Diagnosis: Dorsal fin XII, 16 or 17. Gill rakers 26 to 29 on first

arch. Scales 7 or 8 above lateral line. Origin of dorsal fin to origin of pectoral fin 4.0 or 4.1 in standard length. Least depth of caudal peduncle 8.5 to 9.3 in standard length. First predorsal length 2.2 or 2.3 in standard length. Diameter of orbit 3.3 to 3.8 in head. Length of pectoral fin 3.5 to 3.8 in standard length. Pectoral fin not covered with scales, except basally. Elongate black blotch beneath free margin of preopercular angle. No horizontal stripes on head or body. Scales below lateral line on pectoral region not enlarged. Maxillary not reaching to vertical from center of eye. Preopercular serrae embedded in membranous border of preopercle.

Description: Dorsal fin XII, 16 or 17; anal fin III, 9; pectoral fin rays 16 or 17; caudal fin branched rays 15. Scales 48 to 52 along lateral line, 7 or 8 above lateral line. Gill rakers 16 to 18 on lower limb of first arch, 10 to 12 on upper limb of first arch. Vertebrae 26, including the hypural.

Head 2.5 to 2.7 in standard length. End of head to caudal base 1.6 or 1.7 in standard length. Snout 6.4 to 7.8 in standard length. Maxillary 5.5 to 6.1 in standard length. End of maxillary to origin of pectoral fin 4.2 to 5.0 in standard length. Diameter of orbit 3.3 to 3.8 in head, 1.1 to 1.6 in snout, 1.5 to 1.8 in maxillary, 0.9 to 1.2 in least depth of caudal peduncle. Postorbital length 6.2 to 7.1 in standard length. Ventral length 3.1 to 3.4 in standard length. Greatest depth of body 2.5 to 2.8 in standard length. Spinous dorsal base 2.8 to 3.2 in standard length; soft dorsal base 5.1 to 5.3 in standard length; total dorsal base 1.9 or 2.0 in standard length. First predorsal length 2.2 or 2.3 in standard length; second predorsal length 1.3 or 1.4 in standard length. First postdorsal length 1.4 or 1.5 in standard length; second postdorsal length 2.6 to 3.0 in standard length. Origin of dorsal fin to origin of pectoral fin 4.0 or 4.1 in standard length, to origin of anal fin 1.9 to 2.1 in standard length. Length of soft dorsal fin 4.0 to 4.2 in standard length. Origin of soft dorsal fin to origin of pectoral fin 2.4 to 2.6 in standard length, to origin of pelvic fin 2.1 to 2.3 in standard length, to origin of anal fin 2.9 to 3.2 in standard length. End of soft dorsal fin to end of anal fin 6.4 to 6.9 in standard length. Length of anal fin 4.2 to 5.0 in standard length; preanal length 1.3 or 1.4 in standard length; postanal length 2.6 to 3.0 in standard length. Anal base 6.9 to 8.1 in standard length. Length of pectoral fin 3.5 to 3.8 in standard length. Prepectoral length 2.5 to 2.8 in standard length; postpectoral length 1.5 to 1.7 in standard length. Origin of pectoral fin to origin of pelvic fin 5.9 to 6.1 in standard length, to origin of anal fin 2.5 to 2.8 in standard length. Length of

pelvic fin 4.1 to 4.3 in standard length. Prepelvic length 2.4 or 2.5 in standard length; postpelvic length 1.5 to 1.7 in standard length. Upper length of caudal peduncle 5.5 to 6.6 in standard length; lower length of caudal peduncle 4.5 to 5.2 in standard length. Least depth of caudal peduncle 8.5 to 9.3 in standard length. Upper caudal lobe 3.3 to 3.7 in standard length; lower caudal lobe 3.8 to 4.2 in standard length. Length of middle caudal rays 5.9 to 7.0 in standard length.

Seven specimens were examined ranging from 65 to 112 mm., standard length.

The gray grunt has a muddy gray ground color with stripes of brownish-black; between these there are conspicuous yellow areas.

This species ranges from Florida to the Atlantic coast of tropical America. It is not commonly found in this area.

3. *Haemulon steindachneri* (Jordan and Gilbert)
Roncador raiado

Haemulon caudimacula Steindachner, 1876: 15 (not of Cuvier and Valenciennes).

Diabasis steindachneri Jordan and Gilbert, 1882: 322 (Panama and Mazatlan).

Haemulon steindachneri Jordan and Swain, 1885: 299; Jordan and Evermann, 1898: 1301-1302 (description; synonymy); Gilbert and Starks, 1904: 105 (Panama Bay); Kendall and Radcliffe, 1912: 115 (Acapulco; Perico Island, Panama Bay).

Haemulon schranki Evermann and Jenkins, 1891: 153 (not of Agassiz); Jordan and Fesler, 1893: 473 (not of Agassiz).

Diagnosis: Dorsal fin XII, 15. Gill rakers 23 to 28 on first arch. Scales 7 or 8 above lateral line. Origin of dorsal fin to origin of pectoral fin 4.1 to 4.3 in standard length. Least depth of caudal peduncle 9.0 to 10.2 in standard length. First predorsal length 2.2 or 2.3 in standard length. Diameter of orbit 3.2 to 3.5 in head. Length of pectoral fin about 3.8 in standard length. Pectoral fin not covered with scales, except basally. Elongate black blotch beneath free margin of preopercular angle. No horizontal stripes on head or body. Scales below lateral line on pectoral region not enlarged. Maxillary reaching to vertical from center of eye or beyond. Preopercular serrae free, conspicuous, projecting beyond membranous border of preopercle.

Description: Dorsal fin XII, 15; anal fin III, 8 or 9; pectoral fin rays 16 or 17; caudal fin branched rays 15. Scales 48 to 50 along lateral line, 7 or 8 above lateral line. Gill rakers 14 to 17 on lower limb of first arch, 9 to 11 on upper limb of first arch. Vertebrae 26, including the hypural.

Head 2.6 to 2.8 in standard length. End of head to caudal base 1.5 or 1.6 in standard length. Snout 7.7 to 8.3 in standard length. Maxillary 5.5 to 5.8 in standard length. End of maxillary to origin of pectoral fin 4.4 to 4.6 in standard length. Diameter of orbit 3.2 to 3.5 in head, 1.0 or 1.1 in snout, 1.6 or 1.7 in maxillary, 0.7 to 1.0 in least depth of caudal peduncle. Postorbital length 6.0 to 6.9 in standard length. Ventral length 2.8 to 3.0 in standard length. Greatest depth of body 2.8 or 2.9 in standard length. Spinous dorsal base 2.9 to 3.1 in standard length; soft dorsal base 5.1 to 5.4 in standard length; total dorsal base about 1.9 in standard length. First predorsal length 2.2 or 2.3 in standard length; second predorsal length 1.3 or 1.4 in standard length. First postdorsal length 1.4 or 1.5 in standard length; second postdorsal length 3.0 or 3.1 in standard length. Origin of dorsal fin to origin of pectoral fin 4.1 to 4.3 in standard length, to origin of anal fin 1.9 or 2.0 in standard length. Length of soft dorsal fin 4.2 to 4.5 in standard length. Origin of soft dorsal fin to origin of pectoral fin 2.5 to 2.7 in standard length, to origin of pelvic fin 2.1 or 2.2 in standard length, to origin of anal fin 3.1 to 3.5 in standard length. End of soft dorsal fin to end of anal fin 6.4 to 8.6 in standard length. Length of anal fin 4.4 to 4.9 in standard length. Preanal length 1.3 or 1.4 in standard length; postanal length about 3.0 in standard length. Anal base 6.5 to 7.4 in standard length. Length of pectoral fin about 3.8 in standard length. Prepectoral length 2.6 or 2.7 in standard length; post-pectoral length 1.5 or 1.6 in standard length. Origin of pectoral fin to origin of pelvic fin 6.9 or 7.0 in standard length, to origin of anal fin 2.6 or 2.7 in standard length. Length of pelvic fin 4.5 to 5.0 in standard length. Prepelvic length about 2.5 in standard length; postpelvic length 1.5 or 1.6 in standard length. Upper length of caudal peduncle 6.3 to 6.5 in standard length; lower length of caudal peduncle 5.5 to 5.7 in standard length. Least depth of caudal peduncle 9.0 to 10.2 in standard length. Length of middle caudal rays about 6.5 in standard length.

Three specimens were examined ranging from 54 to 88 mm., standard length.

This seldom seen species has a body of olive or golden-brown and fins of bright golden-yellow.

Not found in this area, the species has as its range both coasts of tropical America and at least as far south as Brazil on the Atlantic side.

4. *Haemulon bonariense* Cuvier and Valenciennes
Black grunt; Ronco prieto; Ponce prieto

Haemulon bonariense Cuvier and Valenciennes, 1830: 174 (Buenos Aires); Jordan and Evermann, 1898: 1297 (description; synonymy).
Haemulon canna Cuvier and Valenciennes, 1830: 233 (Martinique; not of Agassiz).
Haemulon notatum Poey, 1860: 179 (Cuba).
Haemulon retrocurrens Poey, 1868: 236, 461 (Cuba).
Haemulon continuum Poey, 1875: 46 (Cuba).
Haemulon parrae Jordan and Swain, 1885: 292.

Diagnosis: Dorsal fin XII, 15 to 17. Gill rakers 21 to 24 on first arch. Scales 5 or 6 above lateral line. Origin of dorsal fin to origin of pectoral fin 3.8 to 4.2 in standard length. Least depth of caudal peduncle 8.0 to 9.2 in standard length. First predorsal length 2.1 or 2.2 in standard length. Diameter of orbit 2.9 to 4.4 in head. Length of pectoral fin 3.2 to 4.1 in standard length. Pectoral fin not covered with scales, except basally. Elongate black blotch beneath free margin of preopercular angle. No horizontal stripes on head or body. Scales below lateral line on pectoral region not enlarged. Maxillary not reaching to vertical from center of eye. Preopercular serrae embedded in membranous border of preopercle.

Description: Dorsal fin XII, 15 to 17; anal fin III, 8 or 9; pectoral fin rays 16 or 17; caudal fin branched rays 15. Scales 44 to 49 along lateral line, 5 or 6 above lateral line. Gill rakers 12 to 15 on lower limb of first arch, 8 or 9 on on upper limb of first arch. Vertebrae 26, including the hypural.

Head 2.6 to 2.9 in standard length. End of head to caudal base 1.5 to 1.7 in standard length. Snout 7.0 to 8.9 in standard length. Maxillary 6.3 to 7.3 in standard length. End of maxillary to origin of pectoral fin 3.8 to 4.3 in standard length. Diameter of orbit 2.9 to 4.4 in head, 0.8 to 1.7 in snout, 0.9 to 1.7 in maxillary, 0.8 to 1.6 in least depth of caudal peduncle. Postorbital length 5.4 to 7.0 in standard length. Ventral length 2.7 to 3.1 in standard length. Greatest depth of body 2.3 to 2.8 in standard length. Spinous dorsal base 2.8 to 3.2 in standard length; soft dorsal base 4.3 to 5.2 in standard length; total dorsal base 1.8 to 2.0 in standard length. First predorsal length 2.1 or 2.2 in standard length; second predorsal length 1.3 or 1.4 in standard length. First postdorsal length 1.3 to 1.5 in standard length; second postdorsal length 2.7 to 3.1 in standard length. Origin of dorsal fin to origin of pectoral fin 3.8 to 4.2 in standard length, to origin of anal fin 1.8 to 2.0 in standard length. Length of soft dorsal fin 3.3 to 4.7 in standard length. Origin of soft dorsal fin to origin of

pectoral fin 2.2 to 2.6 in standard length, to origin of pelvic fin 2.1 or 2.2 in standard length, to origin of anal fin 2.8 to 3.3 in standard length. End of soft dorsal fin to end of anal fin 6.3 to 7.0 in standard length. Length of anal fin 4.1 to 5.0 in standard length. Preanal length 1.3 or 1.4 in standard length; postanal length 2.8 to 3.1 in standard length. Anal base 6.3 to 8.4 in standard length. Length of pectoral fin 3.2 to 4.1 in standard length. Prepectoral length 2.6 to 2.9 in standard length; postpectoral length 1.5 or 1.6 in standard length. Origin of pectoral fin to origin of pelvic fin 6.0 to 6.8 in standard length, to origin of anal fin 2.4 to 2.6 in standard length. Length of pelvic fin 4.0 to 4.9 in standard length. Prepelvic length 2.4 to 2.6 in standard length; postpelvic length 1.5 or 1.6 in standard length. Upper length of caudal peduncle 6.1 to 6.9 in standard length; lower length of caudal peduncle 4.8 to 5.8 in standard length. Least depth of caudal peduncle 8.0 to 9.2 in standard length. Upper caudal lobe 3.3 to 4.0 in standard length; lower caudal lobe 3.7 to 4.2 in standard length. Length of middle caudal rays 5.0 to 6.8 in standard length.

Eight specimens were examined ranging from 58 to 152 mm., standard length.

This fish varies in appearance. In a dark habitat it may be dusky gray or darker, with brassy spots. In the open it is lighter.

The black grunt ranges from Argentina to South Florida but is extremely uncommon in this area.

5. *Haemulon album* Cuvier and Valenciennes
Margate; Margatefish; Margaret grunt; Jallao; Ronco blanco

Perca marina gibbosa cinerea (margatefish) Catesby, 1743: 2 (Bahamas), pl. 2.
Perca gibbosa Walbaum, 1792: 342 (not of Linnaeus, after Catesby).
Calliodon gibbosus Bloch and Schneider, 1801: 312.
Haemulon album Cuvier and Valenciennes, 1830: 241 (St. Thomas); Jordan and Evermann, 1898: 1295-1296 (description; synonymy).
Haemulon microphthalmum Günther, 1859: 306 (America).
Haemulon gibbosum Jordan and Swain, 1885: 290.

Diagnosis: Dorsal fin XII, 15 or 16. Gill rakers 21 to 25 on first arch. Scales 7 or 8 above lateral line. Origin of dorsal fin to origin of pectoral fin 3.9 to 4.6 in standard length. Least depth of caudal peduncle 8.5 to 10.2 in standard length. First predorsal length 2.1 to 2.4 in standard length. Diameter of orbit 4.8 to 7.7 in head. Length of pectoral fin 3.8 to 4.2 in standard length. Pectoral fin not covered with scales, except basally. No elongate black blotch beneath free margin of preopercular angle. No horizontal stripes on head or body.

Scales below lateral line on pectoral region not enlarged. Maxillary not reaching to vertical from center of eye. Preopercular serrae embedded in membranous border of preopercle.

Description: Dorsal fin XII, 15 or 16; anal fin III, 8; pectoral fin rays 18 or 19; caudal fin branched rays 15. Scales 48 to 52 along lateral line, 7 or 8 above lateral line. Gill rakers 12 to 16 on lower limb of first arch, 8 or 9 on upper limb of first arch. Vertebrae 26, including the hypural.

Head 2.6 to 2.9 in standard length. End of head to caudal base 1.5 or 1.6 in standard length. Snout 6.3 to 7.0 in standard length. Maxillary 6.4 to 7.0 in standard length. End of maxillary to origin of pectoral fin 4.0 to 4.3 in standard length. Diameter of orbit 4.8 to 7.7 in head, 1.8 to 3.4 in snout, 1.9 to 3.2 in maxillary, 1.5 to 2.2 in least depth of caudal peduncle. Postorbital length 6.0 to 7.0 in standard length. Ventral length 3.0 to 3.1 in standard length. Greatest depth of body 2.4 to 2.8 in standard length. Spinous dorsal base 3.1 to 3.6 in standard length; soft dorsal base 4.3 to 5.1 in standard length; total dorsal base 1.9 to 2.1 in standard length. First predorsal length 2.1 to 2.4 in standard length; second predorsal length 1.3 to 1.5 in standard length. First postdorsal length 1.4 to 1.6 in standard length; second postdorsal length 2.6 to 2.9 in standard length. Origin of dorsal fin to origin of pectoral fin 3.9 to 4.6 in standard length, to origin of anal fin 1.9 to 2.1 in standard length. Length of soft dorsal fin 3.6 to 4.3 in standard length. Origin of soft dorsal fin to origin of pectoral fin 2.6 to 2.8 in standard length, to origin of pelvic fin 2.2 to 2.5 in standard length, to origin of anal fin 2.9 to 3.6 in standard length. End of soft dorsal fin to end of anal fin 6.1 to 7.1 in standard length. Length of anal fin 5.0 to 6.1 in standard length. Preanal length about 1.4 in standard length; postanal length 3.0 to 3.2 in standard length. Anal base 6.7 to 9.0 in standard length. Length of pectoral fin 3.8 to 4.2 in standard length. Prepectoral length 2.6 to 2.8 in standard length; postpectoral length 1.6 or 1.7 in standard length. Origin of pectoral fin to origin of pelvic fin 5.6 to 6.2 in standard length, to origin of anal fin 2.6 or 2.7 in standard length. Length of pelvic fin 4.3 to 5.6 in standard length. Prepelvic length 2.4 or 2.5 in standard length; postpelvic length 1.6 or 1.7 in standard length. Upper length of caudal peduncle 5.7 to 6.6 in standard length; lower length of caudal peduncle 4.8 to 5.3 in standard length. Least depth of caudal peduncle 8.5 to 10.2 in standard length. Upper caudal lobe 3.1 to 3.8 in standard length; lower caudal lobe 3.5 to 4.2 in standard length.

Length of middle caudal rays 6.5 to 9.1 in standard length.

Five specimens were examined ranging from 151 to 485 mm., standard length. The 151 mm. specimen was found to have 13 spines in the dorsal fin.

The margate is the largest of the grunts. It has remarkable powers of color change. Its common phase is pearl-gray on the head and body with some scattered darker spots. When disturbed it assumes a mottled phase.

This species ranges from Florida to Brazil.

6. *Haemulon carbonarium* Poey
Caesar grunt; Ronco carbonero

Haemulon carbonarium Poey, 1860a: 176 (Cuba); Poey, 1868: 318; Jordan and Evermann, 1898: 1300-1301 (description; synonymy: Havana, Cuba).

Diagnosis: Dorsal fin XII, 15 or 16. Gill rakers about 24 on first arch. Scales 5 or 6 above lateral line. Origin of dorsal fin to origin of pectoral fin 4.2 or 4.3 in standard length. Least depth of caudal peduncle 9.4 to 10.0 in standard length. First predorsal length about 2.4 in standard length. Diameter of orbit 3.5 or 3.6 in head. Length of pectoral fin 3.7 or 3.8 in standard length. Pectoral fin not covered with scales, except basally. Elongate black blotch beneath free margin of preopercular angle. No horizontal stripes on head or body. Scales below lateral line on pectoral region not enlarged. Maxillary not reaching to vertical from center of eye. Preopercular serrae embedded in membranous border of preopercle.

Description: Dorsal fin XII, 15 or 16; anal fin III, 8 or 9; pectoral fin rays 16 or 17; caudal fin branched rays 15. Scales about 49 along lateral line, 5 or 6 above lateral line. Gill rakers 14 or 15 on lower limb of first arch, 9 or 10 on upper limb of first arch. Vertebrae 26, including the hypural.

Head 2.8 to 3.0 in standard length. End of head to caudal base 1.5 or 1.6 in standard length. Snout 6.5 to 7.0 in standard length. Maxillary 6.9 or 7.0 in standard length. End of maxillary to origin of pectoral fin 4.2 to 4.7 in standard length. Diameter of orbit 3.5 or 3.6 in head, about 1.5 in snout, 1.4 to 1.6 in maxillary, 1.0 to 1.2 in least depth of caudal peduncle. Postorbital length 7.0 to 8.0 in standard length. Ventral length 3.0 to 3.2 in standard length. Greatest depth of body 2.7 or 2.8 in standard length. Spinous dorsal base 3.0 or 3.1 in standard length; soft dorsal base 4.5 to 4.9 in standard length; total dorsal base about 1.9 in standard length. First predorsal length about

2.4 in standard length; second predorsal length about 1.4 in standard length. First postdorsal length 1.4 or 1.5 in standard length; second postdorsal length 2.7 or 2.8 in standard length. Origin of dorsal fin to origin of pectoral fin 4.2 or 4.3 in standard length, to origin of anal fin about 2.0 in standard length. Length of soft dorsal fin 3.8 to 4.0 in standard length. Origin of soft dorsal fin to origin of pectoral fin 2.5 to 2.7 in standard length, to origin of pelvic fin 2.2 or 2.3 in standard length, to origin of anal fin about 3.2 in standard length. End of soft dorsal fin to end of anal fin 6.8 to 7.0 in standard length. Length of anal fin 4.7 to 5.0 in standard length. Preanal length about 1.4 in standard length; postanal length 2.9 or 3.0 in standard length. Anal base 6.7 to 7.5 in standard length. Length of pectoral fin 3.7 or 3.8 in standard length. Prepectoral length 2.6 to 2.9 in standard length; postpectoral length 1.5 or 1.6 in standard length. Origin of pectoral fin to origin of pelvic fin 6.7 or 6.8 in standard length, to origin of anal fin 2.6 or 2.7 in standard length. Length of pelvic fin 4.1 or 4.2 in standard length. Prepelvic length 2.4 to 2.8 in standard length; postpelvic length 1.6 or 1.7 in standard length. Upper length of caudal peduncle 6.0 to 6.3 in standard length; lower length of caudal peduncle 4.9 or 5.0 in standard length. Least depth of caudal peduncle 9.4 to 10.0 in standard length. Upper caudal lobe 3.6 or 3.7 in standard length; lower caudal lobe about 3.9 in standard length. Length of middle caudal rays 6.8 to 7.5 in standard length.

Two specimens were examined ranging from 145 to 175 mm., standard length.

The Caesar grunt is gray to brown on its body. Yellow stripes are often seen on its sides.

This species is rare in our area. It ranges from Florida and Bermuda to Brazil.

7. *Haemulon flavolineatum* (Desmarest)
French grunt; Open-mouthed grunt; Ronco condenado

Diabasis flavolineatus Desmarest, 1823: 35 (Cuba), pl. 2, fig 1.
Haemulon heterodon Cuvier, 1829: 176 (Cuba); Cuvier and Valenciennes, 1830: 255.
Haemulon xanthopteron Cuvier and Valenciennes, 1830: 254 (Martinique).
Haemulon xanthopterum Günther, 1859: 312.
Haemulon flavolineatum Poey, 1868: 309; Jordan and Evermann, 1898: 1306-1307 (description; synonymy; Havana, Cuba); Fowler, 1916: 402(Colón) and 1917: 132(Colón).

Diagnosis: Dorsal fin XII, 14 or 15. Gill rakers 23 to 25 on first arch. Scales 5 or 6 above lateral line. Origin of dorsal fin to origin of

pectoral fin 4.2 to 4.7 in standard length. Least depth of caudal peduncle 9.1 to 10.0 in standard length. First predorsal length 2.3 to 2.6 in standard length. Diameter of orbit 3.0 to 4.0 in head. Length of pectoral fin 3.3 to 3.9 in standard length. Pectoral fin not covered with scales, except basally. Elongate black blotch beneath free margin of preopercular angle. No horizontal stripes on head or body. Scales below lateral line on pectoral region enlarged. Maxillary not reaching to vertical from center of eye. Preopercular serrae embedded in membranous border of preopercle.

Description: Dorsal fin XII, 14 or 15; anal fin III, 8; pectoral fin rays 16 to 18; caudal fin branched rays 15. Scales 48 to 51 along lateral line, 5 or 6 above lateral line. Gill rakers 13 to 15 on lower limb of first arch, 9 to 11 on upper limb of first arch. Vertebrae 26, including the hypural.

Head 2.6 to 2.9 in standard length. End of head to caudal base 1.4 to 1.6 in standard length. Snout 7.4 to 8.0 in standard length. Maxillary 6.1 to 6.8 in standard length. End of maxillary to origin of pectoral fin 4.1 to 4.8 in standard length. Diameter of orbit 3.0 to 4.0 in head, 0.9 to 1.6 in snout, 1.2 to 1.8 in maxillary, 0.8 to 1.2 in least depth of caudal peduncle. Postorbital length 6.5 to 7.8 in standard length. Ventral length 2.6 to 3.2 in standard length. Greatest depth of body 2.6 to 2.9 in standard length. Spinous dorsal base 2.9 to 3.3 in standard length; soft dorsal base 4.4 to 5.6 in standard length; total dorsal base 1.9 or 2.0 in standard length. First predorsal length 2.3 to 2.6 in standard length; second predorsal length 1.3 or 1.4 in standard length. First postdorsal length 1.4 or 1.5 in standard length; second postdorsal length 2.5 to 3.0 in standard length. Origin of dorsal fin to origin of pectoral fin 4.2 to 4.7 in standard length, to origin of anal fin 1.9 to 2.1 in standard length. Length of soft dorsal fin 3.8 to 4.4 in standard length. Origin of soft dorsal fin to origin of pectoral fin 2.4 to 2.7 in standard length, to origin of pelvic fin 2.1 to 2.4 in standard length, to origin of anal fin 3.0 to 3.3 in standard length. End of soft dorsal fin to end of anal fin 6.4 to 8.0 in standard length. Length of anal fin 4.3 to 5.2 in standard length. Preanal length 1.3 to 1.5 in standard length; postanal length 2.8 to 3.1 in standard length. Anal base 7.6 to 8.5 in standard length. Length of pectoral fin 3.3 to 3.9 in standard length. Prepectoral length 2.6 to 2.9 in standard length; postpectoral length 1.4 or 1.5 in standard length. Origin of pectoral fin to origin of pelvic fin 6.3 to 6.9 in standard length, to origin of anal fin 2.5 to 2.7 in standard length. Length

of pelvic fin 4.1 to 4.3 in standard length. Prepelvic length 2.4 to 2.7 in standard length; postpelvic length 1.4 to 1.6 in standard length. Upper length of caudal peduncle 5.6 to 6.4 in standard length; lower length of caudal peduncle 4.4 to 5.1 in standard length. Least depth of caudal peduncle 9.1 to 10.0 in standard length. Upper caudal lobe 3.3 to 3.7 in standard length; lower caudal lobe 3.4 to 4.1 in standard length. Length of middle caudal rays 6.0 to 8.4 in standard length.

Ten specimens were examined ranging from 70 to 157 mm., standard length. The 70 mm. specimen was found to have 42 scales along the lateral line.

The French grunt is often scarcely darker than straw color, but changes in shade occur when it passes from a sandy bottom to the neighborhood of corals. It sometimes displays alternating bluish and brassy lines on its sides.

This species ranges from Florida to Brazil. It is more common in the West Indies than in the Florida Keys.

8. *Haemulon parra* (Desmarest)

Sailor's choice; Ronco blanco; Ronco prieto; Bastard margaret; Ronco

Diabasis parra Desmarest, 1823: 30 (Havana, Cuba), pl.2, fig. 2.
Haemulon caudimacula Cuvier, 1829: 176 (Brazil); Cuvier and Valenciennes, 1830: 226 Günther, 1859: 313; Poey, 1868: 310; Jordan and Gilbert, 1882: 322 (redescription of original type).
Haemulon chromis Broussonet, (in Cuvier and Valenciennes), 1830: 180 (Jamaica); Günther, 1859: 310.
Haemulon canna Agassiz, (*in* Spix), 1831: 130.
Haemulon acutum Poey, 1860a: 180 (Cuba).
Haemulon albidum Poey, 1860a: 181 (Cuba).
Haemulon serratum Poey, 1860a: 181 (Cuba).
Diabasis chromis Jordan and Gilbert, 1883: 924.
Haemulon parra Jordan and Fesler, 1893: 471; Jordan and Evermann, 1898: 1297-1299 (description; synonymy; Key West, Florida); Fowler, 1916: 402 (Colón) and 1917: 132 (Colón).

Diagnosis: Dorsal fin XII, 18 or 19. Gill rakers 21 to 25 on first arch. Scales 5 or 6 above lateral line. Origin of dorsal fin to origin of pectoral fin 3.8 to 4.3 in standard length. Least depth of caudal peduncle 5.7 to 9.3 in standard length. First predorsal length 2.2 to 2.4 in standard length. Diameter of orbit 2.5 to 4.1 in head. Length of pectoral fin 3.6 to 4.8 in standard length. Pectoral fin entirely covered with scales. Elongate black blotch beneath free margin of preopercular angle. No horizontal stripes on head or body. Scales below lateral line on pectoral region not enlarged. Maxillary not

reaching to vertical from center of eye. Preopercular serrae embedded in membranous border of preopercle.

Description: Dorsal fin XII, 18 or 19; anal fin III, 8 or 9; pectoral fin rays 16 to 18; caudal fin branched rays 15. Scales 44 to 51 along lateral line, 5 or 6 above lateral line. Gill rakers 12 to 16 on lower limb of first arch, 6 to 10 on upper limb on first arch. Vertebrae 26, including the hypural.

Head 2.4 to 2.9 in standard length. End of head to caudal base 1.4 to 1.6 in standard length. Snout 6.8 to 8.8 in standard length. Maxillary 6.0 to 6.9 in standard length. End of maxillary to origin of pectoral fin 3.7 to 4.7 in standard length. Diameter of orbit 2.5 to 4.1 in head, 0.7 to 1.6 in snout, 1.1 to 1.7 in maxillary, 0.8 to 1.4 in least depth of caudal peduncle. Postorbital length 5.8 to 7.7 in standard length. Ventral length 2.7 to 3.4 in standard length. Greatest depth of body 2.4 to 3.1 in standard length. Spinous dorsal base 3.0 to 4.2 in standard length; soft dorsal base 4.0 to 4.9 in standard length; total dorsal base 1.8 to 2.3 in standard length. First predorsal length 2.2 to 2.4 in standard length; second predorsal length 1.3 to 1.6 in standard length. First postdorsal length 1.4 or 1.5 in standard length; second postdorsal length 2.3 to 2.8 in standard length. Origin of dorsal fin to origin of pectoral fin 3.8 to 4.3 in standard length, to origin of anal fin 1.8 to 2.3 in standard length. Length of soft dorsal fin 3.2 to 4.0 in standard length. Origin of soft dorsal fin to origin of pectoral fin 2.4 to 2.9 in standard length, to origin of pelvic fin 2.1 to 2.4 in standard length, to origin of anal fin 2.7 to 3.6 in standard length. End of soft dorsal fin to end of anal fin 6.1 to 7.8 in standard length. Length of anal fin 3.7 to 5.0 in standard length. Preanal length 1.3 or 1.4 in standard length; postanal length 2.4 to 3.1 in standard length. Anal base 5.0 to 8.8 in standard length. Length of pectoral fin 3.6 to 4.8 in standard length. Prepectoral length 2.5 to 3.0 in standard length; postpectoral length 1.3 to 1.6 in standard length. Origin of pectoral fin to origin of pelvic fin 5.8 to 7.0 in standard length, to origin of anal fin 2.2 to 2.8 in standard length. Length of pelvic fin 4.0 to 4.5 in standard length. Prepelvic length 2.2 to 2.6 in standard length; postpelvic length 1.3 to 1.6 in standard length. Upper length of caudal peduncle 5.4 to 6.8 in standard length; lower length of caudal peduncle 4.3 to 5.3 in standard length. Least depth of caudal peduncle 5.7 to 9.3 in standard length. Upper caudal lobe 3.3 to 3.5 in standard length; lower caudal lobe 3.4 to 4.0 in standard length. Length of middle caudal rays 3.6 to 6.8 in standard length.

Seventeen specimens were examined ranging from 23 to 173 mm., standard length. The 43 mm. specimen was found to have 15 soft rays in the dorsal fin.

The sailor's choice is usually seen in a plain gray phase with some darker areas. It shows a phase with several stripes and a black blotch at the caudal base.

This species is fairly common and ranges from Florida to Brazil.

9. *Haemulon sciurus* (Shaw)
Yellow grunt; Ronco amarillo; Boar grunt; Humpback grunt; Bluestriped grunt

Anthias formosus Bloch, 1792: 122 (Antilles; not *Perca formosa* of Linnaeus as identified).

Sparus sciurus Shaw, 1803: 439 (Antilles; based on the description and figure of Bloch), pl. 64.

Haemulon elegans Cuvier, 1829: 175 (no description; based on the figure by Bloch); Cuvier and Valenciennes, 1830: 227; Günther, 1859: 306.

Diabasis obliquatus Bennett, 1829: 90 (Jamaica; blue stripes on body said to be oblique, the description not corresponding fully to this or any other known species).

Haemulon similis Castelnau, 1855. (Bahia; description very imperfect).

Haemulon luteum Poey, 1860a: 174 (Cuba).

Haemulon multilineatum Poey, 1860a: 178 (Cuba).

Haemulon hians Haly, 1875: 268 (speciman from Aspinwall).

Diabasis elegans Jordan and Gilbert, 1883: 923.

Haemulon sciurus Jordon, 1885: 126; Jordan and Fesler, 1893: 474; Jordan and Evermann, 1898: 1303-1304 (description; synonymy; Key West, Florida).

Diagnosis: Dorsal fin XII, 16 or 17. Gill rakers 22 to 30 on first arch. Scales 7 or 8 above lateral line. Origin of dorsal fin to origin of pectoral fin 4.0 to 4.8 in standard length. Least depth of caudal peduncle 8.1 to 10.2 in standard length. First predorsal length 2.2 to 2.4 in standard length. Diameter of orbit 2.3 to 4.7 in head. Length of pectoral fin 3.6 to 4.5 in standard length. Pectoral fin not covered with scales except basally. Elongate black blotch beneath free margin of preopercular angle. Horizontal stripes on head and body, about 9 or 10. Scales below lateral line on pectoral region not enlarged. Maxillary reaching to vertical from center of eye or beyond. Preopercular serrae embedded in membranous border of preopercle.

Description: Dorsal fin XII, 16 or 17; anal fin III, 9 or 10; pectoral fin rays 16 or 17; caudal fin branched rays 15. Scales 45 to 51 along lateral line, 7 or 8 above lateral line. Gill rakers 14 to 18 on lower limb of first arch, 6 to 12 on upper limb of first arch. Vertebrae 26, including the hypural.

Head 2.6 to 2.8 in standard length. End of head to caudal base 1.5 to 1.7 in standard length. Snout 6.1 to 8.9 in standard length. Maxillary 5.1 to 6.2 in standard length. End of maxillary to origin of pectoral fin 3.7 to 5.5 in standard length. Diameter of orbit 2.3 to 4.7 in head, 0.6 to 2.2 in snout, 0.9 to 2.5 in maxillary, 0.7 to 1.4 in least depth of caudal peduncle. Postorbital length 5.9 to 7.2 in standard length. Ventral length 2.8 to 3.3 in standard length. Greatest depth of body 2.6 to 2.9 in standard length. Spinous dorsal base 3.1 to 4.1 in standard length; soft dorsal base 4.3 to 5.5 in standard length; total dorsal base 1.9 to 2.2 in standard length. First predorsal length 2.2 to 2.4 in standard length; second predorsal length 1.4 to 1.6 in standard length. First postdorsal length 1.5 or 1.6 in standard length; second postdorsal length 2.4 to 3.2 in standard length. Origin of dorsal fin to origin of pectoral fin 4.0 to 4.8 in standard length, to origin of anal fin 1.9 to 2.5 in standard length. Length of soft dorsal fin 4.0 to 5.5 in standard length. Origin of soft dorsal fin to origin of pectoral fin 2.5 to 3.0 in standard length, to origin of pelvic fin 2.2 to 2.5 in standard length, to origin of anal fin 2.9 to 3.6 in standard length. End of soft dorsal fin to end of anal fin 6.1 to 7.8 in standard length. Length of anal fin 3.9 to 5.6 in standard length. Preanal length 1.3 to 1.5 in standard length; postanal length 2.5 to 3.3 in standard length. Anal base 5.7 to 8.5 in standard length. Length of pectoral fin 3.6 to 4.5 in standard length. Prepectoral length 2.4 to 2.8 in standard length; postpectoral length 1.6 or 1.7 in standard length. Origin of pectoral fin to origin of pelvic fin 6.2 to 7.5 in standard length, to origin of anal fin 2.5 to 3.0 in standard length. Length of pelvic fin 4.0 to 4.9 in standard length. Prepelvic length 2.2 to 2.5 in standard length; postpelvic length 1.6 or 1.7 in standard length. Upper length of caudal peduncle 5.2 to 7.1 in standard length; lower length of caudal peduncle 4.7 to 5.5 in standard length. Least depth of caudal peduncle 8.1 to 10.2 in standard length. Upper caudal lobe 3.2 to 4.1 in standard length; lower caudal lobe 3.3 to 4.2 in standard length. Length of middle caudal rays 4.6 to 8.0 in standard length.

Eighteen specimens were examined ranging from 21 to 258 mm., standard length. The 26 mm. specimen had 14 branched rays. The 42 mm. specimen had 41 scales along the lateral line; the 38 mm. specimen had 4 scales above the lateral line.

The yellow grunt is very changeable in coloration. Its most common markings are alternating yellow and blue stripes running longitudinally through the length of the body.

This is one of the most common species locally. It ranges from Florida to Brazil.

10. *Haemulon plumieri* (Lacépede)
White grunt; Common grunt; Ronco arara; Boar grunt; Ronco grande; Ronco blanco

Guabi coara brasiliensibus Marcgrave, 1648: 163 (Brazil).
Perca marina capite striato (the Grunt) Catesby, 1743, (Bahamas, etc.), pl. 6.
Labrus plumieri Lacépède, 1823: 480 (Martinique; on a copy of a drawing by Plumier), pl. 2, fig. 2.
Haemulon formosum Cuvier, 1829: 175 (Martinique); Günther, 1859: 305 (not *Perca formosa* of Linnaeus).
Haemulon arcuatum Cuvier and Valenciennes, 1833: 356 (Charleston, South Carolina).
Haemulon arara Poey, 1860a: 177 (Cuba).
Haemulon subarcuatum Poey, 1860b: 419 (Cuba).
Diabasis plumieri Jordan and Gilbert, 1882: 603.
Haemulon plumieri Jordan and Gilbert, 1883: 126; Jordan and Evermann, 1898: 1304-1305 (description; synonymy; Key West, Florida); Fowler, 1916: 402 (Colón).

Diagnosis: Dorsal fin XII, 16 to 18. Gill rakers 24 to 27 on first arch. Scales 5 or 6 above lateral line. Origin of dorsal fin to origin of pectoral fin 4.0 to 4.3 in standard length. Least depth of caudal peduncle 8.5 to 9.6 in standard length. First predorsal length 2.2 or 2.3 in standard length. Diameter of orbit 3.2 to 5.2 in head. Length of pectoral fin 3.4 to 4.0 in standard length. Pectoral fin not covered with scales except basally. Elongate black blotch beneath free margin of preopercular angle. Horizontal stripes on head only, about 12. Scales below lateral line on pectoral region not enlarged. Maxillary reaching to vertical from center of eye or beyond. Preopercular serrae embedded in membranous border of preopercle.

Description: Dorsal fin XII, 16 to 18; anal fin III, 10; pectoral fin rays 13 to 17; caudal fin branched rays 15. Scales 47 to 52 along lateral line, 5 or 6 above lateral line. Gill rakers 14 or 15 on lower limb of first arch, 10 to 12 on upper limb of first arch. Vertebrae 26, including the hypural.

Head 2.5 to 2.8 in standard length. End of head to caudal base 1.5 or 1.6 in standard length. Snout 5.2 to 7.8 in standard length. Maxillary 4.8 to 5.5 in standard length. End of maxillary to origin of pectoral fin 3.9 to 5.1 in standard length. Diameter of orbit 3.2 to 5.2 in head, 1.1 to 2.7 in snout, 1.3 to 2.9 in maxillary, 0.8 to 1.5 in least depth of caudal peduncle. Postorbital length 6.3 to 7.7 in standard length. Ventral length 2.8 to 3.6 in standard length. Greatest

depth of body 2.4 to 2.75 in standard length. Spinous dorsal base 2.8 to 3.6 in standard length; soft dorsal base 3.9 to 5.9 in standard length; total dorsal base 1.8 to 2.0 in standard length. First predorsal length 2.2 or 2.3 in standard length; second predorsal length 1.3 to 1.5 in standard length. First postdorsal length 1.4 or 1.5 in standard length; second postdorsal length 2.5 to 3.1 in standard length. Origin of dorsal fin to origin of pectoral fin 4.0 to 4.3 in standard length, to origin of anal fin 1.9 to 2.1 in standard length. Length of soft dorsal fin 3.3 to 4.5 in standard length. Origin of soft dorsal fin to origin of pectoral fin 2.4 to 3.0 in standard length, to origin of pelvic fin 2.2 or 2.3 in standard length, to origin of anal fin 3.0 to 3.2 in standard length. End of soft dorsal fin to end of anal fin 6.1 to 7.6 in standard length. Length of anal fin 4.1 to 5.6 in standard length. Preanal length 1.3 or 1.4 in standard length; postanal length 2.9 to 3.1 in standard length. Anal base 6.4 to 8.6 in standard length. Length of pectoral fin 3.4 to 4.0 in standard length. Prepectoral length 2.4 to 2.7 in standard length; postpectoral length 1.6 or 1.7 in standard length. Origin of pectoral fin to origin of pelvic fin 5.8 to 6.9 in standard length, to origin of anal fin 2.6 to 2.8 in standard length. Length of pelvic fin 3.7 to 4.4 in standard length. Prepelvic length 2.1 to 2.5 in standard length; postpelvic length 1.5 to 1.7 in standard length. Upper length of caudal peduncle 6.0 to 8.0 in standard length; lower length of caudal peduncle 5.0 to 5.6 in standard length. Least depth of caudal peduncle 8.5 to 9.6 in standard length. Upper caudal lobe 3.3 to 3.8 in standard length; lower caudal lobe 3.6 to 4.2 in standard length. Length of middle caudal rays 5.6 to 8.2 in standard length.

Fourteen specimens were examined ranging from 51 to 230 mm., standard length. The 195 mm. specimen had 13 spines in the dorsal fin; the 130 mm. specimen had 14 unbranched caudal rays.

The common grunt is marked by bluish stripes on its head. Its body is bluish-gray with a bronze cast.

This is probably the most common species of the genus *Haemulon* in this area. It ranges from Florida to Brazil.

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TABULAR KEY TO THE WESTERN NORTH

	Dorsal fin	Pectoral fin, entirely covered with scales.	Elongate black blotch beneath free margin of preopercular angle.	Horizontal stripes on head and body; about 9 or 10.	Horizontal stripes on head, only; about 12.	Scales below lateral line on pectoral region enlarged.	Maxillary reaching to vertical from center of eye or beyond.	Preopercular serrae free, conspicuous, projecting beyond membranous border of preopercle.	Origin of dorsal fin to origin of pectoral fin in standard length.	Total number of gill rakers on first arch.	Least depth of caudal peduncle in standard length.
H. melanurum	XII, 17 or 18	no	yes	no	no	no	yes	yes	4.6 to 5.0	22 or 23	9.1 to 10.2
H. macrostomum	XII, 16 or 17	no	yes	no	no	no	no	no	4.0 or 4.1	26 to 29	8.5 to 9.3
H. steindachneri	XII, 15	no	yes	no	no	no	yes	yes	4.1 to 4.3	23 to 28	9.0 to 10.2
H. bonariense	XII, 15 to 17	no	yes	no	no	no	no	no	3.8 to 4.2	21 to 24	8.0 to 9.2
H. album	XII, 15 or 16	no	no	no	no	no	no	no	3.9 to 4.6	21 to 25	8.5 to 10.2
H. carbonarium	XII, 15 or 16	no	yes	no	no	no	no	no	4.2 or 4.3	24	9.4 to 10.0
H. flavolineatum	XII, 14 or 15	no	yes	no	no	yes	no	no	4.2 to 4.7	23 to 25	9.1 to 10.0
H. parra	XII, 18 or 19	yes	yes	no	no	no	no	no	3.8 to 4.3	21 to 25	5.7 to 9.3
H. sciurus	XII, 16 or 17	no	yes	yes	no	no	yes	no	4.0 to 4.8	22 to 30	8.1 to 10.2
H. plumieri	XII, 16 to 18	no	yes	no	yes	no	yes	no	4.0 to 4.3	24 to 27	8.5 to 9.6

ATLANTIC SPECIES OF *HAEMULON*

First predorsal length in standard length.	Postorbital length in standard length.	Scales above lateral line.	Origin of pectoral fin to origin of pelvic fin in standard length.	Length of caudal peduncle in standard length.	Length of maxillary in standard length.	End of maxillary to origin of pectoral fin in standard length.	Diameter of orbit in least depth of caudal peduncle.	Diameter of orbit in snout.	Diameter of orbit in maxillary.	Diameter of orbit in head.	Anal base in standard length.	Length of pelvic fin in standard length.	Length of pectoral fin in standard length.
.4 or .5	6.9 to 7.5	7 or 8	6.1 to 6.9	5.1 to 5.4	5.5 to 6.4	4.3 to 5.1	1.0 to 1.3	1.2 to 1.6	1.7 to 2.0	3.4 to 4.1	6.8 to 7.5	4.5 to 4.7	4.2 to 4.5
2 or .3	6.2 to 7.1	7 or 8	5.9 to 6.1	4.5 to 5.2	5.5 to 6.1	4.2 to 5.0	0.9 to 1.2	1.1 to 1.6	1.5 to 1.8	3.3 to 3.8	6.9 to 8.1	4.1 to 4.3	3.5 to 3.8
2 or .3	6.0 to 6.9	7 or 8	6.9 or 7.0	5.5 to 5.7	5.5 to 5.8	4.4 to 4.6	0.7 to 1.0	1.0 or 1.1	1.6 or 1.7	3.2 to 3.5	6.5 to 7.4	4.5 to 5.0	3.8
1 or .2	5.4 to 7.0	5 or 6	6.0 to 6.8	4.8 to 5.8	6.3 to 7.3	3.8 to 4.3	0.8 to 1.6	0.8 to 1.7	0.9 to 1.7	2.9 to 4.4	6.3 to 8.4	4.0 to 4.9	3.2 to 4.1
1 to .4	6.0 to 7.0	7 or 8	5.6 to 6.2	4.8 to 5.3	6.4 to 7.0	4.0 to 4.3	1.5 to 2.2	1.8 to 3.4	1.9 to 3.2	4.8 to 7.7	6.7 to 9.0	4.3 to 5.6	3.8 to 4.2
.4	7.0 to 8.0	5 or 6	6.7 or 6.8	4.9 or 5.0	6.9 or 7.0	4.2 to 4.7	1.0 to 1.2	1.5	1.4 to 1.6	3.5 or 3.6	6.7 to 7.5	4.1 or 4.2	3.7 or 3.8
3 to .6	6.5 to 7.8	5 or 6	6.3 to 6.9	4.4 to 5.1	6.1 to 6.8	4.1 to 4.8	0.8 to 1.2	0.9 to 1.6	1.2 to 1.8	3.0 to 4.0	7.6 to 8.5	4.1 to 4.3	3.3 to 3.9
2 to .4	5.8 to 7.7	5 or 6	5.8 to 7.0	4.3 to 5.3	6.0 to 6.9	3.7 to 4.7	0.8 to 1.4	0.7 to 1.6	1.1 to 1.7	2.5 to 4.1	5.0 to 8.8	4.0 to 4.5	3.6 to 4.8
2 to .4	5.9 to 7.2	7 or 8	6.2 to 7.5	4.7 to 5.5	5.1 to 6.2	3.7 to 5.5	0.7 to 1.4	0.6 to 2.2	0.9 to 2.5	2.3 to 4.7	5.7 to 8.5	4.0 to 4.9	3.6 to 4.5
2 or .3	6.3 to 7.7	5 or 6	5.8 to 6.9	5.0 to 5.6	4.8 to 5.5	3.9 to 5.1	0.8 to 1.5	1.1 to 2.7	1.3 to 2.9	3.2 to 5.2	6.4 to 8.6	3.7 to 4.4	3.4 to 4.0

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REMARKS ON THE CLIMATE OF SOUTHERN FLORIDA[1]

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ABSTRACT

The climate of the State of Florida is discussed and the distribution of continentality analysed. The unexpectedly high degree of continentality of the Florida Keys is explained in terms of the prevailing winds.

The State of Florida is a low-lying peninsula extending between the approximate latitudes of 31° and 25° and comprising about 55,000 square miles of land area. It is surrounded, except on the north, by the waters of the Atlantic Ocean and the Gulf of Mexico. There are about 3,700 miles of indented coast line, and no point in the State is more than 60 miles from salt water. The highest point in the State is only 325 feet above sea level and most of the interior ranges in elevation from 50 to about 100 feet. The coastal areas are low and flat and indented by many bays and marshy inlets. (Norton, 1941). The main part of southern Florida south of Lake Okeechobee is less than 25 feet above sea level, the only exception being the Talbot formation area southwest of Lake Okeechobee, which area is 25 to 42 feet above sea level. (Parker and Cooke, 1944).

The State of Florida extends over nearly six degrees of latitude and lies in the southern portion of the transitional area between the westerlies and the trade winds. Therefore, to speak of Florida as a climatic unity is likely to be misleading. Little literature exists, however, on the particular features that distinguish the tropical part of Florida from the rest of the state. Carson (1951) has in a comprehensive way tried to isolate some of the factors chiefly responsible for the remarkable development of Florida's southeastern coast and seems to have shown that the unique climate is the basic reason for the steady, rapid growth in population and business in the above area. The climate of the southernmost part of peninsular Florida is worthwhile considering from another point of view.

Within the rather wide range of atmospheric conditions there is an infinite variety of combinations of climatic values, of their frequencies, and of their diurnal and annual variations. It is therefore natural to attempt to group kindred climates and to obtain a classification that will permit the establishment of regional boundaries between areas of

1 Contribution No. 80 from the Marine Laboratory, University of Miami.

relatively uniform climatic conditions. Such boundaries usually define geographic units. The establishment of climatic categories is by no means easy. The best that can be achieved is a classification of climate for a specific purpose rather than a climatic taxonomy. The purpose of a climatic classification may be, for example, to establish limits of areas suitable for a given crop plant. (Landsberg, 1945). Actually, it is the task of climatology to find characteristic limits and to outline suitable boundaries which delineate biological provinces in terms of climatic elements. (Landsberg, 1947).

The best climatic classification so far proposed is that of Köppen (1931). It is based mainly on temperature and precipitation, because these two factors have the most obvious effects. The fundamental quantities on which Köppen's climate classification is mainly based are the annual mean temperatures; the annual mean amounts of precipitation; both the mean temperatures and the mean amounts of precipitation during the months of their maxima and the minima and in addition, the type of the annual march of both of the elements in question. The Köppen classification has been criticized by several geographers from various points of view. Nevertheless, it is still today more generally accepted than any other comparable system.

Following Köppen, five great groups of climate are recognized, two of which must be taken into consideration in connection of the climate of Florida. In the low latitudes near the equator is a winterless region *A* with adequate rainfall. This is the humid tropics, and the climate is generally referred to as *tropical rainy climate*. The humid middle latitudes, with their seasonal contrasts in temperature, are divided into two climatic groups: one in which the winters are mild and short, the *wet subtropical climate C,* and the other, in which they are severe and long, *D*.

The poleward boundary of the tropical rainy climates, *A*, is, according to Köppen, approximately the isotherm of 64.4°F (18°C) for the coolest month of the year. This boundary (Fig. 1) crosses peninsular Florida approximately along the 27th latitude roughly following a curved line joining Fort Myers, Lake Okeechobee, and Melbourne. The temperature mentioned was selected (Trewartha, 1943) because it was found to coincide reasonably well with the poleward limit of certain plants, such as the various palms, which grow only in the warmest regions, and which cannot tolerate marked seasonal changes in temperature. Normally the tropical rainy climates

extend farthest poleward along the eastern or windward sides of the continents, as in the case of Florida.

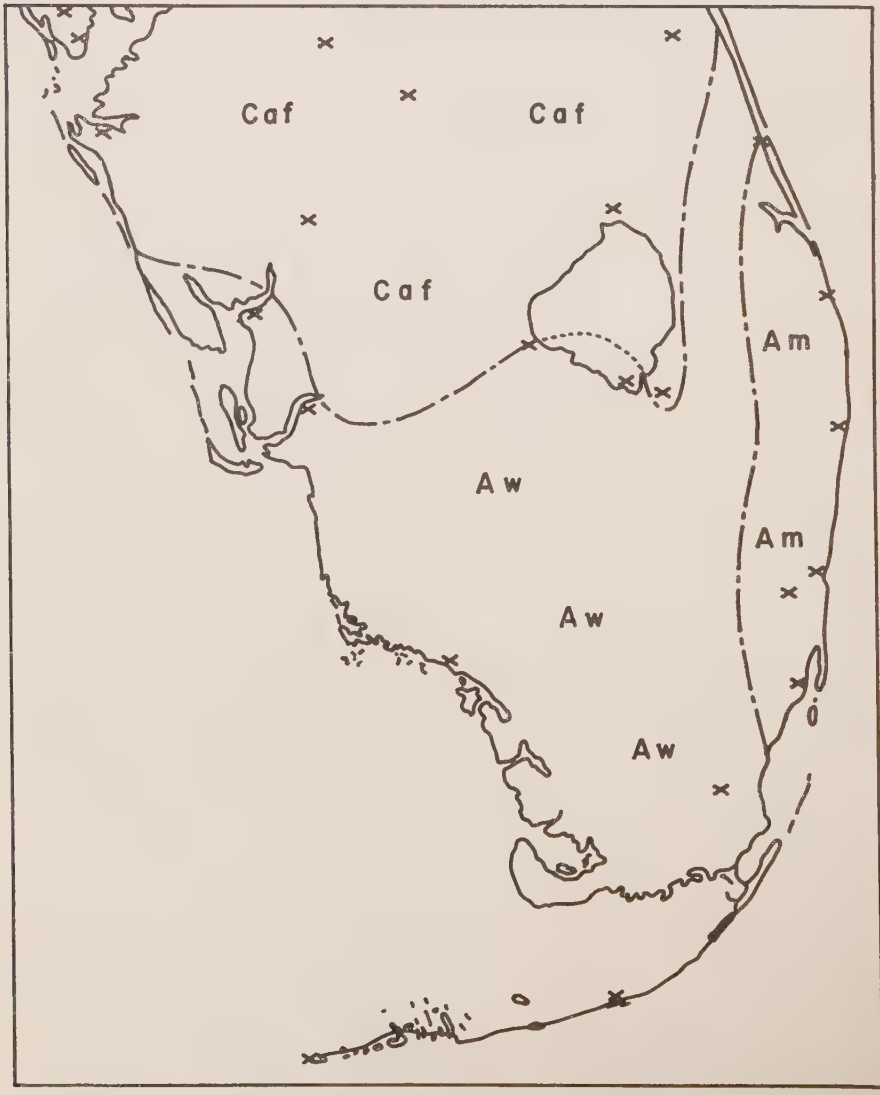

FIGURE 1. Boundary lines in Southern Florida between climatic types *Caf*, (humid mesothermal climate, warm summer, with no dry season). *Aw*, (tropical savanna climate), and *Am*, (transitional tropical climate characterized by virgin forest in spite of a dry season).

The greater portion of Florida belongs to the wet subtropical climate, (humid mesothermal climate), *C*. This intermediate climate type is characterized by changeableness of the weather, which results from the fact that the middle latitudes are a realm of conflict between contrasting air masses expelled from polar and tropical regions. In the case of Florida, the climate type is *Caf*, (Trewartha, 1943), the symbol *a* meaning that the warmest month is over 71.6°F (22°C), and the symbol *f* indicating the nonexistence of a dry season. According to Köppen's classification, climate of a humid mesothermal area is winter-dry (*Caw*) if at least ten times as much rain is precipitated in the wettest month of summer as in the driest month of winter. This is not the case in the humid mesothermal part of Florida, for which reason it belongs to the *Caf* climate type.

In order to analyze the influence of different factors on the climate of Florida, not only the latitude and the lack of any marked differences in the altitude, but also the *maritime influence* and its distribution must be considered.

It is generally known that the distribution of continents and oceans dominates the major climatic characters of the various parts of the earth to such an extent that the most important climatic differences on the surface of the earth are those which exist between a continental and an oceanic area. The increased annual range of temperature inland is perhaps the most striking effect of the continental surface on climate and the annual range *A* is therefore taken as a measure of the climatic factor called continentality. (Conrad, 1951). This author (Hela, 1952), in a recent study of the regional distribution of the continentality in the climate of the oceans, has proposed the following new formula for the index of continentality.

$$K = \frac{1.97A}{0.92 + \sin(\varphi - 53)} - 13.3$$

In this formula

K is the index of continentality $(0 - 100)$,

A is the annual range of temperature, °C, and

φ is the geographical latitude.

The regional distribution of the continentality in the state of Florida (Fig. 2) is mainly characterized by the southward increasing maritime influence, i.e., by the moderating effect of the Atlantic Ocean and the Gulf of Mexico on temperature contrasts. In the northern part of peninsular Florida the continentality is about 40 per cent, and in the southern part less than 20 per cent. This decrease is to a certain

extent due simply to increasing distance from the main body of the North American continent, the continental influence of the relatively narrow peninsula itself being quite small. On the eastern coast the continentality seems to be, in general, about 5 units lower than in the western part of the interior of the peninsula, the asymmetry depending on the influence of the prevailing easterly trade winds. In spite of the easterlies, a weak maritime influence of the Gulf of Mexico, also, can be traced along the western coast of the peninsula.

Perhaps the most striking features in the regional distribution of the continentality of Florida are the great differences between the northern and southern parts of the peninsula, and the location of the

FIGURE 2. Regional distribution of the continentality in the State of Florida.

minimum continentality area on the southeast coast of Florida, roughly between Hypoluxo and Miami, rather than in the region of the Florida Keys. These two features need additional explanation.

When interpreting the details of Fig. 2, the significance of the trade winds is especially important. Only in September, October, and November is the east-west axis of the Azores-Bermuda high located far enough north to bring the northernmost part of the Florida east coast well within the trade belt. The southern part of the state is in this tropical easterly belt during the entire year. This difference between the northern and southern parts of peninsular Florida brings about further marked effects upon the difference in continentality.

If, in the computation of A in the above formula, the average temperatures of the warmest and coldest months are replaced by the average annual maximum and minimum temperatures or by the highest and lowest temperatures ever observed, then the computed "continentality" of the Florida Keys becomes much less than that of the southeastern coastal area. Traditionally, however, the monthly means are used for this purpose, and thus Key West, in fact, becomes more continental than Fort Lauderdale: the average January temperature in Fort Lauderdale is not more than 1°F lower than that of Key West but the average July temperature in Fort Lauderdale is 1.8°F lower than in Key West, the annual range of temperature thus being less in Fort Lauderdale than in Key West. This surprising fact can be interpreted on the basis of the wind data.

In Fig. 3 is given the annual variation of the resulting wind in the area of the Straits of Florida off Miami. The figure shows that southern Florida is included throughout the year in the trade wind region. In addition, it shows that the resulting winds blow in the summer from southeast. The resulting winds of the winter months are a joint effect of the easterly trade winds and the northerly or northwesterly winds occurring from time to time. On the basis of this annual fluctuation, the relatively high continentality of the Florida Keys can be interpreted as a result of the following two factors: (a) in the winter time some of the cold northerly winds reaching southernmost Florida are slightly warmer in Fort Lauderdale than in Key West due to the great distance of the warm Florida Straits area over which they have traveled before reaching Fort Lauderdale. For this reason the average temperature of the coldest month at Fort Lauderdale and in general in the southeasternmost part of Florida is unexpectedly high. (b) The high average July temperature of Key West must be due to the follow-

ing maritime effect: the diurnal range of temperature at Key West remains small and therefore the nights are warm. Thus the average temperature of the warmest month is unexpectedly high.

We have stated that the southeastern coastal area of peninsular Florida is under a very strong maritime influence. This influence must be found also in the march of other climatic elements, especially in the wind data. However, the wind observations are in most cases not accurate enough for detailed study. For the present purpose, it is more significant that the same effect is found in the precipitation data, i.e., in the type of the annual fluctuation of the precipitation. This consideration may also be connected with Köppen's climate classification.

Within the tropical rainy climate type (*A*), rainfall contrasts bring about three principal recognizable types. The first of them is the *tropical rainforest climate, Af,* in which there is no dry season, all months having more than 2.4 in. (6 cm) of precipitation. The second type, *Aw,* called *tropical savanna climate,* has a relatively long and severe dry season, and the rainfall of the wet period is insufficient to

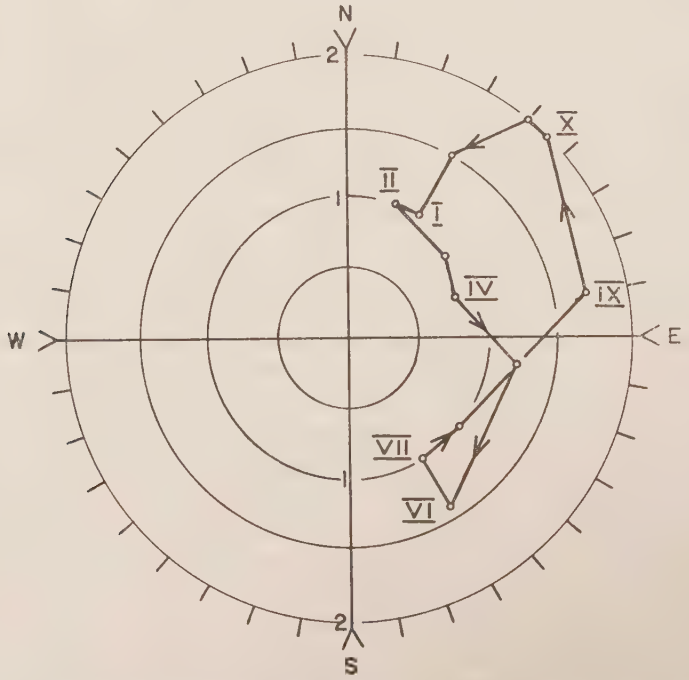

FIGURE 3. Annual variation of the resulting wind (in Beauf.) in the area of the Straits of Florida off Miami.

to compensate for the drought. In this climate the dense rainforests of *Af* are replaced by lighter, more open forests and tall grass. The third, called by Trewartha (1943) *"monsoon rainforest climate", Am,* is an intermediate climate type between the tropical rainforest climate and the tropical savanna climate. It was originally referred to by Köppen as a *"transitional tropical climate characterized by virgin forest in spite of a dry season."* This subtype, *Am,* roughly, has the heavy rainfall of Af and the seasonal distribution of *Aw.*

Köppen has given a graph from which the equation defining the boundary line between *Aw* and *Am* climates can be derived; it is, according to Conrad,

$$p = 10 - \frac{r}{25}$$

where p denotes the average rainfall of the month with the least precipitation, and r the average annual rainfall, both in centimeters. Characteristically the type *Am* is, in general, located "along coasts backed by mountains or plateau escarpments against which a monsoon wind blows for at least a partof the year. The rainfall of the wet season is so great that in spite of a marked dry season the subsoil is not dried out sufficiently to prevent the growth of an evergreen rainforest." (Trewartha, 1943).

A difference in the annual march of the precipitation, similar to that between the climate types *Am* and *Aw,* may be seen at the weather

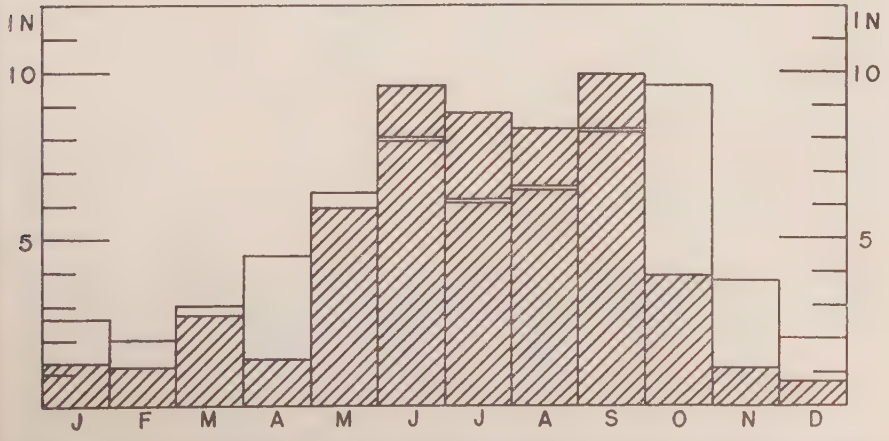

FIGURE 4. The amounts of precipitation during different months, in inches, in Fort Lauderdale (unshaded columns) and in the Everglades (shaded columns).

stations of the eastern and western part of tropical Florida. In Fig. 4 the amounts of precipitation during different months are given for Fort Lauderdale and for the Everglades. The dry season of the latter apparently is much more distinctly marked. When the data of the weather stations of tropical Florida are plotted into a graph giving the mathematical boundaries between the different types of tropical rainy climate (Fig. 5) it is readily seen that, according to the temperature and precipitation data, the southeastern coastal area of peninsular Florida belongs to the *Am* type, whereas the main part of tropical Florida belongs to the savanna type, *Aw*. The border between these two purely climatic regions is given also in Fig. 1.

Conrad (1950) has emphasized that, since the weather stations are generally far distant from one another, the mathematically correct interpolation of the values, critical for the location of the border lines between different climate types, is not an entirely reliable procedure. Therefore, in general, botanical facts should also be considered in

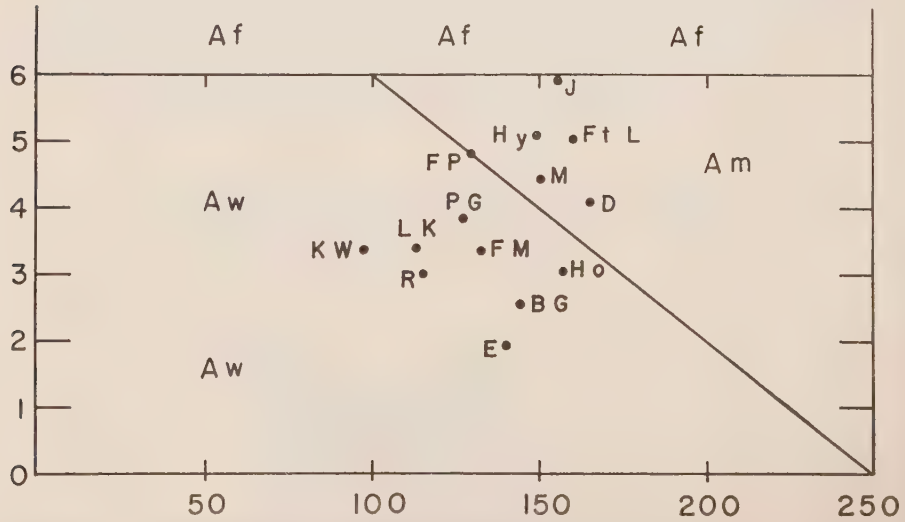

FIGURE 5. Climatological boundaries between the different types of tropical rainy climate (*Af, Am,* and *Aw*). As abscissa the annual amount of precipitation and as ordinate the average rainfall of the month with the least precipitation is used, both in cm. The symbols correspond to the following weather stations. Broward: Davie (D); Fort Lauderdale (Ft L). Charlotte: Punta Gorda (P G). Collier: Everglades (E). Dade: Homestead (Ho); Miami (M). Lee: Fort Myers (F M). Monroe: Key West (K W); Long Key (L K). Palm Beach: Belle Glade (B G); Hypoluxo (Hy); Jupiter (J); Ritta (R). St. Lucie: Fort Pierce (F P).

drawing these border lines. In our case, the border between the climate types *Am* and *Aw* does not seem to follow the corresponding botanical border line. Therefore, in this case we have to consider our border between two climatic types, *a priori,* as a border line between regions defined by the climatic data alone rather than as a border between two logically corresponding geographic regions. One of the reasons for this is, of course, that the soil conditions in tropical Florida also vary regionally to a considerable extent. In addition, the very peculiar drainage conditions of tropical Florida, especially of the Everglades, together with the varying soil conditions, bring about regional variation of different factors, under the influence of which the distribution of the geographic, and especially the plant geographic, regions cannot exactly correspond to the climatic regions. Nevertheless, there exists a marked difference in the continentality of the climate itself between the eastern maritime coastal part of tropical Florida and the more continental central and western part.

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THE DISTRIBUTION OF MARINE BORERS IN THE MIAMI AREA IN RELATION TO ECOLOGICAL CONDITIONS[1]

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Abstract

Ecological observations were made on marine wood-borers at Miami, Florida, from December 1948 to November 1949 and from March 1950 to January 1951.

The most abundant organism was *Teredo* (*Lyrodus*) *pedicellata* De Quatrefages which was active throughout the year. An increase in attack was noted in early summer and early autumn during both periods of observation. Maximum growth rate was observed in midsummer.

Variation in *Limnoria* attack was the same as that of *Teredo pedicellata* during the first period, but occurred in bi-monthly cycles in the second period of study.

Sea water temperatures at Miami were not limiting, but higher summer temperatures were believed to have caused an increase in the growth and boring rates of *Teredo pedicellata.*

At stations of uniform high salinity, *Teredo pedicellata* was found in greater numbers near the surface probably because of a negative geotactic response. *Limnoria* was concentrated near the bottom because of a negative photic response.

At stations of low salinity (up-river), borer attack decreased from the mudline, where higher salinities were evident, to the surface.

The horizontal distribution of all the borers appeared to be associated with the amount of wood in the surrounding area. The highest concentration of organisms was observed in the upper Biscayne Bay area particularly where many wood pilings were present.

Introduction

Prior to the present century, literature concerning marine borers dealt primarily with the description and distribution of species. The current interest in their ecology, especially in the United States and Canada, is based on the effect of hydrographic conditions on seasonal changes in growth and boring activity.

At San Francisco, severe infestations of *Teredo navalis* were most evident during the summer and autumn months (Kofoid and Miller, 1927). At this time sea water temperature and salinity ranged from 14-20°C and 20-30°/$_{00}$ respectively. Winter temperatures below 14°C corresponded with decreasing teredo activity. Although a subsequent increase in temperature occurred with the changing season,

1 Contribution No. 79 from the Marine Laboratory, University of Miami. These investigations were aided by a contract between the Office of Naval Research and the University of Miami in cooperation with the U. S. Navy Bureau of Yards and Docks.

heavy attack intensity was not experienced in the spring. This was ascribed to lowered salinities caused by increased rainfall and excess fresh water drainage into harbor areas. Investigation of the limiting values for *Teredo navalis* revealed that salinities as low as 9 or 10°/$_{00}$ were ultimately lethal. Continued existence was observed, however, when these values were raised 5°/$_{00}$ for a few months of the year.

On the North Atlantic coast of America, maximum shipworm activity was also observed during the summer and autumn. Temperature studies revealed that under natural conditions the spawning of *Teredo navalis* was activated above 11 or 12°C (Grave, 1928). This corresponded with the findings of M'Gonigle and M'Gonigle (1925) and M'Gonigle (1926) that 13°C was the minimum temperature at which larvae were found in the sea water. The same authors stated that the range of salinities in which active teredos were found was similar to that observed on the west coast of America.

A certain amount of resistance to extreme changes in salinity has been attributed to the shipworm's use of its pallets in closing off the entrance to the burrow. Under adverse conditions, the organism's siphons are withdrawn and the pallets extruded into the mouth of the boring tube where they fit tightly. Constant salinity is thus maintained within for a considerable time although changes are inevitable as outside water diffuses through the wood. Roch (1931) observed specimens of *Teredo navalis* which remained for six weeks with their siphons withdrawn in this manner. Reappearance of the siphons occurred when the organisms were transferred to normal sea water.

Investigations on *Limnoria lignorum* behavior show that limitation of its activity generally corresponds with very low salinities or lowered salinities accompanied by low temperature. Low temperatures alone are apparently not inhibitive. Laboratory observations of this organism at San Francisco (Miller, 1926, and Kofoid and Miller, 1927) revealed that salinities below 16°/$_{00}$, were associated with decreased boring and reproductive rates, and at 10°/$_{00}$, death ensued within 16 days. These conditions existed under natural circumstances during the spring months with the onset of heavy rains and increased fresh water drainage in the bay. During the winter, normal salinities were encountered but temperatures dropped as low as 8°C. Nevertheless, *Limnoria* activity seemed unaffected. Similar behavior is recorded on the east coast of Canada by Henderson (1924).

Although the feeding habits of marine borers are of particular interest, this subject has not been thoroughly studied. Many authors

believe that plankton is important in the diet of shipworms (Sigerfoos, 1907; Barrows, 1917; Kofoid and Miller, 1927). On the other hand, the investigations of Dore and Miller (1923) revealed that a large percentage of cellulose and hemicellulose is lost from wood borings during their passage through the shipworm's digestive tract. This, together with the discovery of cellulytic activity in the shipworm (Boynton and Miller, 1927), indicates that nutritive use is made of at least part of the wood in which boring occurs. Later Roch (1931) found that when teredo-ridden wood panels were suspended in sea water devoid of plankton, the organisms were able to live indefinitely and without injury. No mention was made, however, of the possible utilization of bacteria or other microscopic forms present in the sea water.

Little is known of nutrition in *Limnoria*, but recent studies by Ray and Julian (1952) have shown the presence of cellulase activity in this organism.

In view of the imperfect state of knowledge regarding shipworm ecology, especially in the Miami area, the present study was undertaken as part of a joint investigation by members of the Staff of the Marine Laboratory, University of Miami. The work herein described is concerned with seasonal occurence, depth distribution, and variation with location. From December 1948 to November 1949, distribution surveys were carried out at 13 stations selected for their different ecological conditions. The studies were continued under a more intensive program from March 1950 to January 1951. The number of stations was reduced to four, and data concerned with salinity, temperature and feeding habits were collected. In addition, growth rates were compared with those obtained by Isham, Moore and Smith (1951) on the local species of shipworm.

I wish to express my indebtedness to Mr. L. B. Isham for collecting the data during the 1949 period and for his help in introducing me to the material studied.

Methods

Borers were collected by exposing in the sea water clear yellow pine panels cut to the dimensions of ½ x 6 x 10 inches. These were fastened in pairs to bronze sashweight chain cut into lengths corresponding to the water depth at each station. The chain was anchored to the bottom with cement blocks while the upper portion was kept afloat by buoys or similar means.

The seasonal distribution of boring organisms was accomplished

by tabulating the types and number of borers present in panels collected at monthly intervals. Most of the material for depth distribution studies was collected in 1949. During that time, the average monthly number of borers present at various depths was obtained at three stations representing conditions in the Miami River, at the mouth of the Miami River, and in Biscayne Bay.

The basis of growth rate measurement was the total volume occupied by a teredo burrow. The teredo was removed and the burrow filled with melted paraffin. After allowing it to set, the wax mold was placed in a vial calibrated in tenths of a milliliter and containing water. The amount of displacement was recorded as the volume of the burrow. In many instances the displacement was too small for a reading to be made. It was then necessary to measure the volume of several wax pellets, representing as many burrows, and note the average.

The increase in borer size was determined by exposing panels in pairs, and, after one month's exposure, measuring the burrow volume of several individuals in one of the pair. It was assumed that the average of these was approximately that of the other member of the pair. The latter remained exposed for a second month after which volume measurements were obtained as before. Their average minus the one recorded for the previous month was taken to be the growth increment for that period.

Water temperatures at each of the test stations were measured by means of maximum-minimum thermometers secured to the chain holding the test panels. To prevent their corrosion, a coating of methacrylate resin was applied and renewed monthly. Salinities were obtained monthly with hydrometers.

Plankton collections were also made each month. The samples, obtained with a Clarke-Bumpus apparatus and # 20 plankton net, were recorded in terms of dry weight per liter of water filtered.

Results

Collecting Stations. A detailed description of these as well as the other data collected is shown in the APPENDIX. Of the 13 stations used during 1949, four were retained for use in the 1950 survey: Stations 2, 12, 5 and 9. At Station 9, situated near Fowey Light, the monthly number of borings was too low to be considered significant. In addition, the location was such that the test panels were subjected

to heavy wave action and were consequently lost on several occasions. The station was discontinued in September 1950.

Borer Species. All the identifications of borers were made by Mr. Herman Doochin. The shipworm species encountered were *Teredo (Lyrodus) pedicellata* De Quatrefages, *Bankia caribbea* Clench and Turner, *Bankia fimbriatula* Moll and Roch, *Phyloteredo sp.* and *Martesia sp.* Of these, *Teredo pedicellata* was in the great majority, the other species being relatively scarce.

Limnoria lignorum Rathke and several other species of *Limnoria* were also found in large numbers. The latter have not as yet been determined, nor their relative abundance estimated; consequently where reference is made to *Limnoria,* all forms of this group are included.

Monthly Attack Rate. The total monthly numbers of borings obtained at Stations 2, 5 and 12 during the two years of study are shown in Table II. Due to the abundance of *Teredo pedicellata* and the scarcity of other forms, it was assumed that small borings made by shipworms too young to be identified were started by the former.

The comparison of 1949 and 1950 data shows similarity in the attack rate of *Teredo pedicellata.* Although borer attachment occurred throughout the year, it was most evident from early summer to early fall with distinct peaks in activity in June and October.

Limnoria attack differed markedly in the two periods of observation. During 1949, this activity was most noticeable from March to October while in 1950, an increase in the number of these organisms appeared every second month.

Difference in Yearly Attack. In addition to the monthly attack rate, Table II also shows that in 1949, a greater number of borers were evident than in the year that followed. The same was apparent at each of the three stations retained for intensive study during the second year of observation (Table III).

Difference in Attack by Stations. The horizontal borer distribution during 1949 is recorded in Table IV. Generally, a greater concentration of the organisms was apparent in the upper bay region. Subsequent observations at the three selected stations showed the greatest amount of attack at Station 2 and the least at Station 5 (Table III).

Vertical Distribution. Attack throughout the vertical column at the 13

original stations is shown in Table IV. Indications are that borer infestation is most abundant near the bottom; however further studies at individual stations reveal that this is not always the case with regard to *Teredo pedicellata*. At Station 13, in the Miami River, *Limnoria* were few in number at all depths. The shipworms, though scarce in the upper layers, were more apparent near the bottom. The water was predominantly fresh at this location with the exception of a more saline layer, resulting from tidal action, at the mudline. Greater borer activity was evident at Station 12 (mouth of the Miami River) throughout the vertical column and especially at the bottom. Salinities were higher than up-river, but the surface layers showed evidence of dilution with the fresher waters from river drainage. Borer behavior at Station 2 was noteworthy because of the uniform high salinity at all depths. Under these conditions, *Teredo pedicellata* was present in greater numbers at the surface while the reverse was true of *Limnoria* (Fig. I).

Growth Rate. The only shipworm present in sufficient numbers for these measurements was *Teredo pedicellata*. The procedures used were impractical as far as *Limnoria* growth was concerned. Though teredo growth occurred throughout the year, an increase in rate occurred during the summer months (Table V). This is in agreement with the observations of Isham, Moore and Smith (1951) on the same species. The maximum exposure time of the panels used was two months, and no crowding of shipworms was observed.

Hydrographic Conditions. Monthly temperatures and salinities are shown in Tables VI and VII. Briefly, they indicate summer readings to be higher than those obtained during the winter. Though temperatures as high as 36°C were recorded, the low values typical of northern waters were not encountered. Low salinities were found in the surface layers of Station 12, but these occurred only on occasion and were not considered limiting.

Plankton quantities (Table VIII) were highest during the spring and early summer and concur with the observations of Smith, Williams and Davis (1950).

Discussion

During the present investigation, principal attention was devoted to *Teredo pedicellata*, the most abundant boring organism in the Miami

area. Consequently most of the observations and conclusions relate to this species.

Hydrographic Conditions and Attack and Growth Rate. At first view the over-all behavior pattern of *Teredo pedicellata* appeared to be in direct contrast to that of shipworms in northern waters. The latter are reported to exhibit marked changes in boring and breeding behavior which is accounted for by limiting values in hydrographic conditions. At times these may include low salinity (due to increased fresh water drainage) or near freezing temperatures which results in the cessation of activity, especially that of breeding. On the other hand, the survey

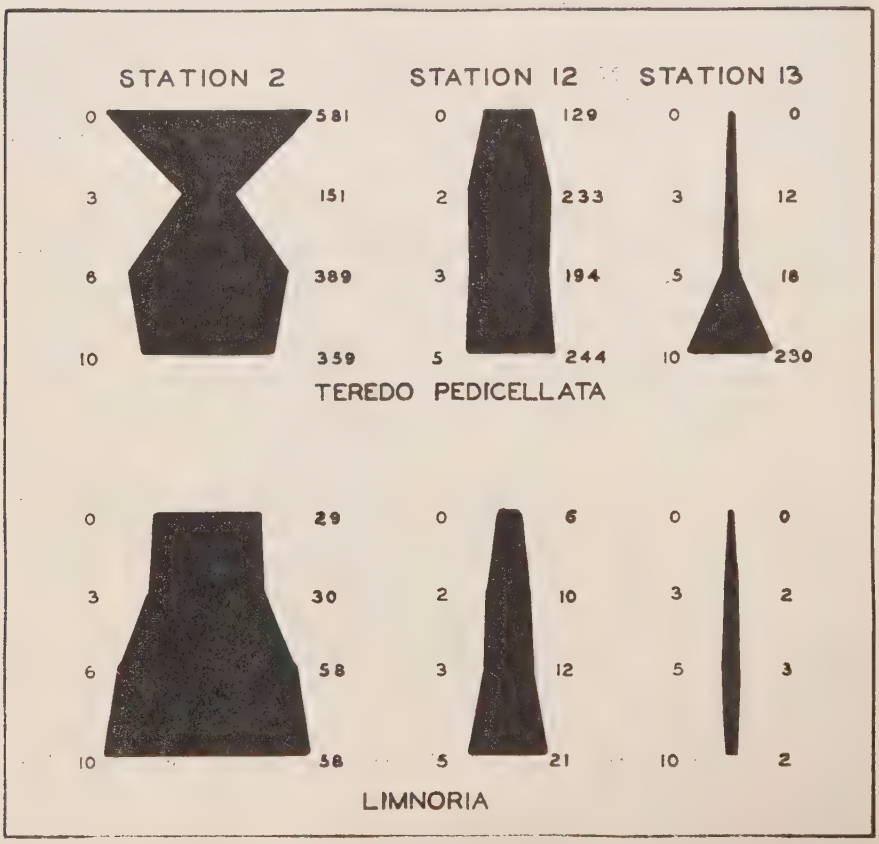


FIGURE 1. Vertical distribution of *Teredo pedicellata* and *Limnoria* under bay and river conditions. Numbers at the left of each figure indicate the depth of water in feet from surface to bottom. Numbers at the right of each figure represent the average monthly number of borers.

at Miami revealed *Teredo pedicellata* to be actively breeding and boring throughout the year. Here limiting hydrographic conditions were seldom encountered, except at stations in the Miami River. Nevertheless, a seasonal change in both attack rate and growth was apparent. To determine the possible effect on this behavior by the aforementioned conditions, the monthly temperature, salinity, and plankton data obtained during 1950 were examined. Significant correlations between growth rate and temperature and between attack rate and temperature were obtained (Figs. 2 and 3). No correlation with plankton or salinity was found.

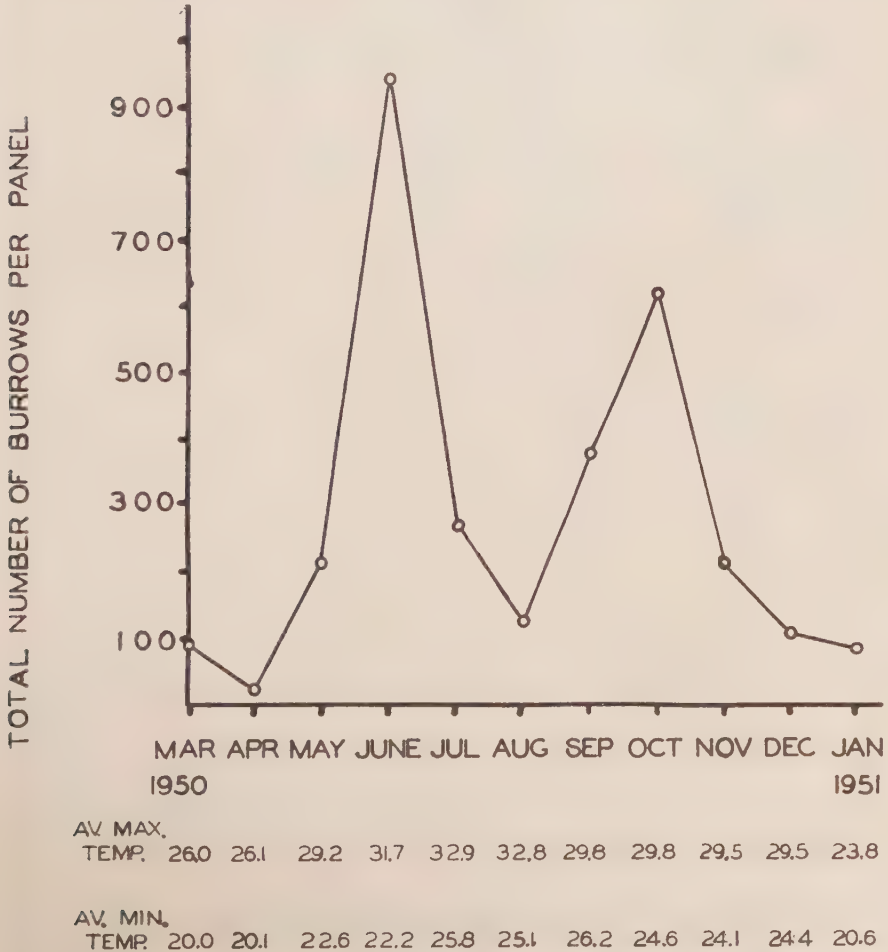
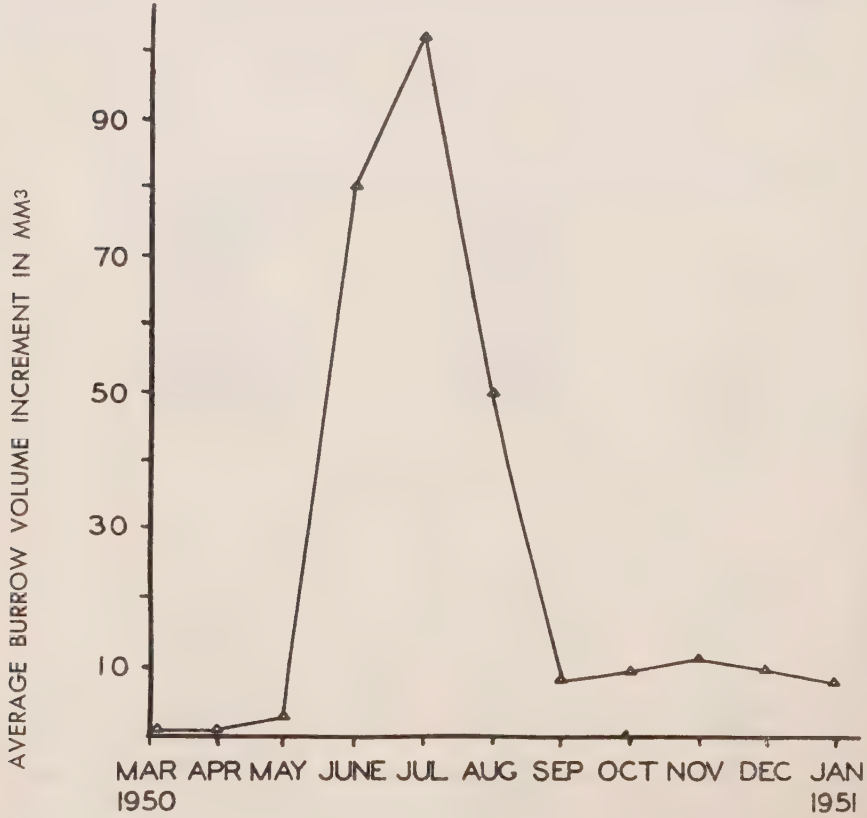


FIGURE 2. Monthly attack rate of *Teredo pedicellata* at Stations 2, 5 and 12.

The influence of temperature on borer behavior may be more readily understood in northern waters where near-zero figures have been recorded. Although these do not occur in Miami, the change from winter to summer temperatures is of the same order of magnitude as the former, being in the neighborhood of 10°C. That observable variation in activity may be caused by small temperature changes, especially if such changes are within the active range of the organism



	MAR	APR	MAY	JUNE	JUL	AUG	SEP	OCT	NOV	DEC	JAN
AV. MAX. TEMP.	26.0	26.1	29.2	31.7	32.9	32.8	29.8	29.8	29.5	29.5	23.8
AV. MIN. TEMP.	20.0	20.1	22.6	22.2	25.8	25.1	26.2	24.6	24.1	24.4	20.6

FIGURE 3. Growth rate of *Teredo pedicellata* at Stations 2, 5 and 12.

in question, is not unlikely. Certain poikilothermic animals have been found to respond to one-half degree changes in a five degree span within the active range (Prosser *et al.*, 1950).

Despite the fact that no significant correlation was found between teredo activity and plankton, this factor cannot be entirely ignored. The actual importance of wood in the diet has not been completely investigated, and it is not unlikely that certain essential substances may be obtained elsewhere, possibly in the plankton.

Concerning *Limnoria*, the lack of agreement between the monthly attack rates during the two years has not been fully explained at present. In view of the presence of several species in the Miami area, it is possible that the seasonal behavior of any one species may be obscured by that of the others.

Vertical Distribution and Ecological Factors. The effect of river conditions on borer behavior was clearly reflected in the different attack rates at Stations 2, 12, and 13. The reason for increased numbers of borers near the bottom at low salinity stations (13 and 12) is probably twofold. First, lower salinities have been reported as unfavorable to borer activity, and second, the specific gravity of the larvae is greater than that of the fresh surface waters, hence there is a tendency for them to sink. The latter is especially true of *Teredo*.

The situation at Station 2 was somewhat different since salinities here were much the same throughout the vertical column. With regard to the shipworm, the investigations of Isham, Springer and Smith (1951) have shown that the larvae exhibit a negative geotaxis under normal conditions. This would explain the large numbers of adult shipworms found in the upper attachment panels.

The same authors found that the degree of settlement of *Limnoria* was inversely proportional to increasing light intensity. This is consistent with the observed high concentration of these organisms near the bottom.

Attack by Stations and Yearly Attack. The difference in attack rate at the four original stations may be interpreted on the basis of the amount of wood available for attachment at each location. Station 9, it was noted, had extremely few borers. This is probably related to the fact that the nearest source of heavy infestation, the Miami-Miami Beach area, was about ten miles distant, and no other wood structures were in the vicinity. A somewhat greater attack was apparent at Station 5 where a few scattered pilings were evident, although these were

placed at a considerable distance from the attachment panels. Consequently, the number of borers found was not comparable to that typical of the upper bay region. Station 12, second in attack intensity, was situated in an area populated with many pilings and down-river from the North River piers and yacht basins. The largest number of marine wood structures was found at Station 2, which was located near the middle of the Causeway Terminal Yacht Basin, and it was here that most of the borer attack was observed.

The over-all drop in attack rate between 1949 and 1950, was thought to be caused by the removal of pilings in and around Miami. As a result, a survey was made of the local marine construction companies in an effort to discover the number, place, and location of pilings removed during the two years. The outcome of the survey showed that most of those withdrawn and replaced were not in the locality of the test stations, and the number so listed was small, compared with the total quantity of pilings present. Thus, the reduction of attack could not be ascribed to this factor.

From the foregoing discussion, it appears that while hydrographic conditions do not approach limiting values, borer activity, specifically shipworm activity, may exhibit seasonal rhythm which is related to changes in these conditions. Furthermore, vertical distribution of both *Limnoria* and *Teredo* is influenced by more than one factor. In areas of continued low salinity, the response to this condition predominates, but under normal conditions, the distribution of these organisms may be due to geotactic (*Teredo*) or photic (*Limnoria*) stimuli. Horizontal distribution under normal conditions is dependent on the amount of wood substrate available for the attachment of young.

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Appendix

TABLE I

Descriptions of Collecting Stations, Dec. 1948 - Jan. 1949

Station	Location	Description
1	North of Miami Women's Club, 1737 N. Bayshore Drive.	Large city sewer and other drainage openings in vicinity. Several pilings and piers attached to concrete sea wall. * (2).
2	Causeway Terminal Yacht Basin.	Near-Harbor entrance inside Government Cut. Many pilings and small-boat piers. Detailed hydrographic data in TABLES VI and VII.
3	Miami Beach Boat Slips, 19th St. and Purdy Ave.	* (1)
4	East shore of Biscayne Bay between West Point and Hurricane Harbor.	Wooden structures in vicinity consisted of a row of pilings. * (3).
5	Hurricane Harbor, Key Biscayne.	Dredged Harbor 15-25 feet deep. At time of survey, few old pilings located at one end. Detailed hydrographic data in TABLES VI and VII.
6	Southeast tip of Virginia Key.	Few wooden structures present. Hydrographic conditions similar to Station 4.
7	Reference Marker 20 in Biscayne Channel	Few wooden structures present. * (5).
8	Reference Marker 6, channel north of Chicken Key.	Few wooden structures present. * (11).
9	500 yards north of lighthouse at Fowey Rocks.	No wooden structures present. Detailed hydrographic data in TABLES VI and VII.
10	Outside (east) Elliot Key.	Shoreline of ocean in contact with southward drift. * (8).
11	Inside (west) Elliot Key.	* (7).
12	Piling-braced sea wall at mouth of Miami River.	Many pilings in vicinity. Detailed hydrographic data in TABLES VI and VII.
13	Up-river in boat yard at 1st St. and S. E. 5th St.	Upper layers of the water almost fresh. Near the bottom layer of sea water from bay's tidal circulation.

* Hydrographic data appears in Smith, Williams and Davis (1950). Figures in parentheses correspond to the numbers of these stations used by the authors.

TABLE II

MONTHLY ATTACK RATE OF MARINE BORERS AT STATIONS 2, 5 AND 12
Expressed as total number of borings in all panels.

Month	*Teredo pedicellata* plus young borings	*Bankia fimbriatula* and *Bankia caribbea*	*Martesia sp.*	*Limnoria spp.*
Dec. 1948	318	148	4	58
Jan. 1949	309	0	0	74
Feb.	490	4	14	67
Mar.	1043	0	0	173
Apr.	8803	1	0	177
May	6051	0	0	253
June	9264	5	1	517
July	841	2	4	189
Aug.	1649	49	9	287
Sept.	5253	0	3	349
Oct.	9440	0	7	256
Nov.	1539	13	0	38
Mar. 1950	93	0	0	39
Apr.	25	4	0	138
May	211	10	0	27
June	948	0	0	174
July	269	0	0	74
Aug.	130	9	0	149
Sept.	381	0	0	46
Oct.	628	2	0	98
Nov.	227	0	3	113
Dec.	107	0	2	57
Jan. 1951	90	0	2	185

TABLE III

ATTACK RATE BY STATIONS AND DIFFERENCE IN ATTACK BETWEEN 1949 AND 1950

Expressed as the average number of borers per panel per month.

Station	*Teredo pedicellata* plus young borings.		*Limnoria spp.*	
	Dec. 1948-Nov. 1949	March 1950-Jan. 1951	Dec. 1948-Nov. 1949	March 1950-Jan. 1951
2	2190	106	168	91
12	1903	83	49	8
5	126	17	2	1

TABLE IV

VERTICAL AND HORIZONTAL DISTRIBUTION OF BORERS AT 13 STATIONS DEC. 1948-NOV. 1949

Expressed as average monthly number of borings per panel

Station	Depth (ft.)	*Teredo pedicellata* plus young borings	*Limnoria spp.*	*Bankia fimbriatula* and *Bankia caribbea*	*Martesia sp.*
1	Surf.	63	3	2	2
	6	90	8	23	2
	12	204	3	2	1
	20	210	2	3	1
2	Surf.	889	29	1	1
	3	271	30	0	0
	6	508	31	8	1
	10	522	58	1	0
3	Surf.	121	69	7	5
	6	1009	83	7	7
	12	907	83	3	9
	15	1855	158	3	10
4	Surf.	0	7	0	0
	2	2	7	0	0
	4	3	13	0	0
	6	1	25	0	0
5	Surf.	16	0	0	0
	6	35	2	0	0
	10	44	0	0	0
	20	31	0	0	0
6	Surf.	3	13	0	0
	5	6	25	0	0
	10	18	46	0	0
	15	20	52	0	0
7	Surf.	2	0	0	0
	6	6	1	0	0
	15	3	1	0	0
	20	23	2	0	0
8	Surf.	0	16	0	0
	5	0	102	0	0
	10	0	88	0	0
	15	2	106	0	0
9	Surf.	5	1	0	0
	6	1	1	0	0
	15	0	1	0	0
	20	0	1	0	0
10	Surf.	15	3	1	0
	5	5	15	0	0
	10	2	6	0	0
	15	1	21	0	0
11	Surf.	0	4	0	0
	3	0	11	0	0
	6	0	30	0	0
	10	0	29	0	0
12	Surf.	355	6	1	0
	2	522	10	0	0
	3	325	12	3	0
	5	701	21	6	0
13	Surf.	1	0	0	0
	3	73	2	0	0
	5	109	3	0	0
	10	588	2	0	0

TABLE V

AVERAGE MONTHLY GROWTH RATE OF *Teredo pedicellata* AT STATIONS 2, 5 AND 12. MARCH 1950-JAN. 1951

Expressed in terms of burrow volume (mm.^{3}).

Month	Burrow Volume (mm.^{3})
March	0.3
April	0.3
May	3
June	80
July	102
Aug.	50
Sept.	8
Oct.	10
Nov.	12
Dec.	10
Jan.	8

TABLE VI

MONTHLY MAXIMUM AND MINIMUM TEMPERATURES (°C) AT STATIONS 2, 5, 12 AND 9. MARCH 1950-JAN. 1951

	Station 2				Station 12			
	Surface		Bottom		Surface		Bottom	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
March	25.8*		25.8*		26.5*		26.5*	
April	27.5*		26.5*		29.0*		27.7*	
May	29.4	23.8	29.4	22.7	31.1	17.7	30.0	25.5
June	32.8	20.5	31.7	19.4	31.7	17.5	29.4	25.0
July	32.2	23.3	31.6	24.4	31.1	26.6	34.1	30.0
Aug.	30.0	24.5	31.1	22.2	36.7	30.0	30.0	25.0
Sept.	31.1	25.5	27.7	26.6	31.1	27.7	30.0	25.5
Oct.	29.0	24.4	30.2	21.7	30.1	26.5	31.1	26.0
Nov.	30.0	25.0	30.0	19.3	29.0	24.4	29.2	25.8
Dec.	29.8	24.8	30.1	20.0	29.1	24.8	29.2	25.5
Jan.	24.2	20.1	20.0	19.5	24.2	19.5	23.0	19.0

	Station 5				Station 9			
	Surface		Bottom		Surface		Bottom	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
March	26.0*		25.5*		24.0*		23.9*	
April	23.5*		22.5*		24.5*		24.3*	
May	28.0	24.4	27.2	21.7	28.0	25.5	28.5	25.0
June	33.3	28.8	32.2	22.2	31.5	28.5	31.4	28.0
July	32.8	25.0	35.5	25.5	31.4	28.3	31.4	28.3
Aug.	32.2	22.2	36.7	26.7	...	...	...	...
Sept.	31.1	25.5	27.7	26.6	...	...	...	...
Oct.	30.5	22.2	28.1	26.5	...	...	...	...
Nov.	30.5	23.1	28.3	27.1	...	...	...	...
Dec.	29.8	23.0	28.8	28.0	...	...	...	...
Jan.	25.2	20.3	26.1	25.0	...	...	...	...

* Spot temperatures taken before maximum-minimum thermometers were obtained.

TABLE VII

MONTHLY SALINITY READINGS AT STATIONS 2, 5, 12 AND 9. MARCH 1950 - JAN. 1951

Readings obtained with hydrometer and expressed in °/₀₀.

	Station 2		Station 12		Station 5		Station 9	
Month	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
March	36.5	36.5	24.8	35.3	36.8	36.6	35.8	35.8
April	37.3	36.9	26.8	34.3	34.3	34.2	35.8	35.7
May	38 0	38.2	34.0	37.2	38.0	38.3	36.8	37.0
June	39.1	39.0	28.4	31.8	39.6	38.8	38.1	38.0
July	34.0	34.6	20.8	22.9	38.7	38.8	36.8	29.3
Aug.	34.0	34.8	13.0	33.2	37.6	36.8	36.2	36.2
Sept.	36.4	37.2	22.0	25.2	37.0	36.7	36.0	36.1
Oct.	33.8	35.2	20.1	28.4	32.0	32.1	-	-
Nov.	34.2	34.8	19.5	26.5	34.1	33.9	-	-
Dec.	34.6	34.6	10.3	26.6	33.8	33.7	-	-
Jan.	36.2	36.2	18.0	28.2	34.0	34.0	-	-

TABLE VIII

AVERAGE MONTHLY PLANKTON QUANTITIES AT STATIONS 2, 5 AND 12. APRIL 1950 - JAN. 1951

Expressed in gm. x 10-4 dry wt./liter sea water.

Month	gm. plankton X 10^{-4}
April	135
May	244
June	490
July	129
Aug.	5
Sept.	5
Oct.	21
Nov.	14
Dec.	3
Jan.	5

Instructions for Preparation of Manuscripts

CONTRIBUTIONS will be considered which deal with research in the marine sciences, directly or indirectly related to the southeastern United States and the Caribbean area. Papers dealing solely with the economic or applied aspects of commercial fisheries will not be accepted.

Manuscripts may be submitted in languages other than English but publication will be in English only. Where possible, arrangements will be made for translation.

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Bibliographical references must be indicated by author's name and year of publication. References should be listed under that heading in alphabetical order of authors. Each reference should include the last name followed by initials or the first name. Co-authors should be listed with initials preceding the last name. The date should appear next to the author's name, followed by a complete title, in lower case except for the first word. The publisher, city and pagination should follow, in the case of books. The names of periodicals should be abbreviated as in "World List of Scientific Periodicals," Oxford. The volume is then given in arabic numerals underlined for italics, followed by the number in brackets and the pagination preceded by a colon. After the first line of each reference the copy is indented.

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